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Quality assurance testing of the ECLOX-M in detecting terrorism threats in Louisiana's public drinking water systems

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QUALITY ASSURANCE TESTING OF THE ECLOX-M™ IN DETECTING TERRORISM THREATS IN LOUISIANA'S PUBLIC DRINKING WATER SYSTEMS

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ABBREVIATIONS LIST

ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
CWS	Community Water System
DHS	Department of Homeland Security
ETV	Environmental Technology Verification
FBI	Federal Bureau of Investigation
IARC	International Agency for Research on Cancer
LDAF	Louisiana Department of Agriculture and Forestry
LDEQ	Louisiana Department of Environmental Quality
MCL	Maximum Contaminant Load
MCLG	Maximum Contaminant Load Goal
MSA	Metropolitan Statistical Area
NCWS	Non-Community Water System
NOHSC	National Occupational Health and Safety Commission
NPDWRs	National Primary Drinking Water Regulations
NSDWRs	National Secondary Drinking Water Regulations
OPH	Office of Public Health
PVC	Polyvinyl Chloride
PWS	Public Water System
SDWA	Safe Drinking Water Act
SDWP	Safe Drinking Water Program
TDS	Total Dissolved Solids

THM	Trihalomethane
UIC	Underground Injection Control
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration

ABSTRACT

A quality assurance testing of the ECLOX-M ™, a rapid water quality indicator used in potential terrorist attacks, was evaluated for its adequacy in nine regional Louisiana water systems. The ECLOX-M™ system uses enhanced chemiluminescence to measure toxicity in water by integration of a mixture of luminol ($C_8H_7O_3N_3$), and an oxidant in the presence of a catalyst enzyme – horseradish peroxidase (HRP). Water samples were tested for chemiluminescence, chlorine content, pH, and arsenic and/or nerve agent/pesticide contamination. In addition, three toxic industrial chemical standards were evaluated (mercury, a volatile liquid mixture, and a volatile gas mixture) and two nerve agent/pesticide standards (atrazine, and a regulated pesticide mixture). Additional tests included: three replicates of each contaminant at two concentration levels; three replicates of each regional water sample; and chemical standard spikes on each water sample. A metal mixture and a volatile organic compound (VOC) mixture were evaluated to determine the machine's sensitivity to chemical mixtures. Lastly, two ECLOX-M™'s were tested simultaneously to determine their precision and accuracy. Testing revealed a significant difference in the inhibition % for the nine regional water samples. A one-way ANOVA and a student T-test revealed a significant difference in inhibition % between concentrations for all chemical standards tested. A trend was seen with chemicals and water samples in which the standard deviation for inhibition % increases as the toxicity of the sample decreases. An additive effect on inhibition % was hypothesized for the chemical mixtures. Instead an inhibitory effect was seen for the metal mixture, and a synergistic effect was seen for the VOC mixture. This suggests that the ECLOX-M™ is not capable of detecting components or interactions between

components within a mixture. The simultaneous testing revealed no significant difference between the performances of the two machines. Lastly, there was a significant difference between the regional water sample pH levels, ($p \leq 0.01$). It is suggested that water systems with complex water matrices consider using multiple testing methods, as ECLOX-M™ alone is not an accurate indicator of contamination. Detection of added contaminants is difficult to ascertain if clean water produces high light inhibition.

INTRODUCTION

The events of September 11, 2001 have had a lasting impact on the United States' interest regarding homeland security. Evaluation of our nation's current emergency preparedness, vulnerabilities of critical infrastructures, and the nation's water systems have become top priority. Even though no known attacks have taken place on U.S. water supplies, the likelihood of an event could be devastating to public health, national security and economic services.

In response to the events of September 11, the Bioterrorism Preparedness and Response Act of 2002 required all community water systems that serve 3,300 to 100,000 people, perform and certify to the United States Environmental Protection Agency (U.S.EPA) that they have conducted a vulnerability assessment. Continued intelligence data indicates that the Al-Qaeda terrorist network planned to conduct surveillance of U.S. dams, reservoirs, and water supply systems as potential soft targets which are lightly secured. Water infrastructure experts at the U.S. EPA, Department of Homeland Security (DHS) and the Federal Bureau of Investigation (FBI) have determined that threats depend on, but are not limited to several factors. These factors include 1) chemical or biological agents employed in the attack, 2) the quantities used to contaminate public water supplies, 3) the water treatment processes in use by the water utility, and 4) the location of the contamination within the treatment facility. The sheer quantity of toxic agent required to overcome the effect of dilution reduces the likelihood that reservoirs could be contaminated sufficiently to affect public health.

Surveillance systems help federal, state and local agencies detect natural or terrorist related disease outbreaks or chemical contaminations in drinking water systems.

They implement communication strategies to disseminate information about public health and the environment to the general public, industry, and government agencies, and for interagency collaboration. The Center for Disease Control (CDC) encourages states to participate in a surveillance system they have set up for detecting waterborne disease outbreaks associated with drinking water and recreational waters. Louisiana currently has a surveillance system for hazardous waste sites that links the Louisiana Tumor Registry data with the Louisiana Department of Environmental Quality's (LDEQ) data on groundwater contaminants and drinking water data from the Louisiana Office of Public Health (OPH), Safe Drinking Water Program (SDWP). Another surveillance system incorporates quantifying the deaths of animals or aquatic life after a suspected contamination. Several natural processes exist that could reduce, but not eliminate, the toxicity levels of agents introduced prior to water treatment. These processes are evaporation and degradation brought on by exposure to sunlight.

Knowing the threat of contamination exists, the U.S. EPA awarded a grant to the Louisiana OPH SDWP. Grant funding will be used to train and provide technical assistance to water system operators to improve security and emergency preparedness. Included in the grant was money to afford the state to purchase and provide a rapid-screening surveillance system which will aid the regional water treatment facilities in detecting contaminated drinking water. The ECLOX-M™ system provides a simple to use, rapid-screening of water samples to give water utilities rapid knowledge of the relative toxicity of the water at their site.

The system works by using a photometer to read light output from a chemiluminescence reaction. Chemiluminescence is a biochemical reaction involving

luminol, an oxidant and a horseradish peroxidase enzyme. The system can detect if certain toxins are present in the water by quantifying the light inhibition as a measure of water quality. Severn Trent Services has marketed the ECLOX-M™ kit to the UK Armed Forces for making field evaluations of drinking water quality for their troops. The kits have been adopted further by the UK Ministry of Defense as well as engineers and environmental technicians to evaluate raw water quality.

In-house analytical testing for water utilities is used for specific chemical parameters and microorganisms. Standard analyses include testing for cyanide, volatile organic compounds, trace metals, total organic carbon and wet chemical parameters such as pH, alkalinity, conductivity, and bacterial cultures. These tests are specific analytical methods used for screening to detect chemicals and organisms to indicate the contamination of raw water and drinking water. These tests are not always very accurate, as illustrated in cases with bacterial plate counts and the possibility of accidental contamination.

SCOPE OF STUDY

Nine public health regions in the state of Louisiana have received the ECLOX-M™ systems to use in their water treatment facilities for sampling and analytical response to contaminant threats and attacks on their water supplies. The scope of this study is to evaluate water from a water treatment facility in a selected city in each of the nine public health regions. The sites selected are based upon the following criteria: geography of the region, water source (ground or surface water), water treatment (chlorination or no disinfection process), and population size (both large and small water systems are at risk and vulnerable for attack). Water samples are taken in tandem with

normal state mandated sanitary surveys. The water collected at each facility is routinely analyzed at the OPH central lab with gas chromatography for potential interferences and/or trace amounts of chemicals found as background levels in the water. The goal of this research is to conduct a quality assurance test on the ECLOX-M™ system to evaluate its adequacy for use in the public health regions as an indicator of water quality. Its response and testing capabilities to various contaminants (potentially used in a threat or terrorist attack) will demonstrate its usefulness and accuracy in being able to rapidly give results on a wide range of chemicals. The chemicals tested on the ECLOX-M™ as standards, and spiked water samples include: heavy metals, triazine herbicides, carbamate pesticides, and volatile liquid and gas mixtures. Although the ECLOX-M™ system can provide a rapid evaluation of relative water quality at a water treatment facility, it is up to the user or supporting agency to take the appropriate action to the contamination level, based on the level of inhibition.

LITERATURE REVIEW

ROLE OF PUBLIC HEALTH IN DRINKING WATER

After the wake of events following the Oklahoma City Federal Building attack in 1995, and the World Trade Center and Pentagon in 2001, the threat of national security and terrorism was on the forefront of all political and governmental agendas. The United States clearly had entered a new period of security concerns. As technology advances and terrorists get smarter, targets for terrorism have shifted from physical attacks on people, buildings, vehicles, airplanes and ships, to chemical and biological attacks through the air, water, food and even mail systems. The United States government, its states, and publicly and privately owned companies, have all been on alert and have seen the need for vulnerability assessments and security for their land and buildings, employees, citizens, and business infrastructure. The U.S. had to start thinking more seriously about agroterrorism and threats to the public water supplies as being potential targets for terrorist groups.

In 1998, President Clinton signed the Presidential Decision Directive 63 (PDD 63) – "Protecting America's Critical Infrastructures" – which identified eight critical infrastructures throughout the nation. Attacks on these infrastructures could be devastating to the health and economic foundation of the country. They are, in no particular order: banking and finance, water, oil and gas, electric power, information technology, transportation, telecommunications and emergency services (law enforcement, fire, rescue and public health). The water category includes both drinking water and wastewater. The President's Commission on Critical Infrastructure Protection

(1998) stated that it is critical for a public water supply to have adequate amounts of water available on demand at sufficient pressure and be safe to use.

The state of Louisiana has been no stranger to this new way of thinking, and following the events of September 11, 2001, quickly set up an agency for Bioterrorism Preparedness and Emergency Response, supported by the DHS. This agency has a vision and a responsibility to public health, and has realized the need for greater protection of our drinking water supplies. Therefore, they supported the Louisiana Department of Health and Hospitals (DHH), OPH, SDWP in having quick and precise ways to detect possible terrorist contamination in the public drinking water supplies.

Even though the *probability* of a specific individual water or wastewater system being the target of a terrorist attack is miniscule, the *possibility* of the system becoming a target is real. The consequences of such an attack could be significant, even catastrophic in terms of potential casualties, economic consequences and psychological impact. Uninterrupted provision of safe drinking water, water treatment, and removal of municipal wastewater are absolute public health necessities. Loss of the ability for utilities to guarantee either of these critical functions would cause a major disruption in the daily life of the American population.

ASSESSING TERRORISM RISKS FOR WATER SYSTEMS

The Office of Domestic Preparedness has identified commonly identified critical components of water systems:

- Administrative assets
    - Personnel, records
- Source Water
- Treatment Facilities
- Water storage facilities
    - Clearwells, tanks and reservoirs

- Transmission systems
    - Drinking water distribution lines, wastewater collection systems, pump stations
- Power supply and delivery
    - Substations, transmission lines, transformers
- Communications
    - Telephone, radio, internet/intranet (15).

These components are most vulnerable to failure due to natural disasters or intentional damage, and could render an entire system inoperative. They are the components that need the most protection.

In determining system vulnerabilities it is first important to know what the objective of the water system is and who its customers are: is it providing potable water to the general public, sanitary water to industrial sites, or water for firefighters? Next, evaluating how the system utility operates (source water, treatment processes, water storage, distribution) can give information on points of failure within the system (15). Specific assets at a facility should be evaluated for unforeseen attacks. For example, interference with pumps that maintain flow and distribution, interruption of electricity, or contamination of a distribution system with chemical, biological, or radiological contaminants could cause long-term disruption of service. Lastly, the likelihood of malevolent acts being carried out and their impact on a system must be evaluated. Intentional acts can impact a system by 1) the loss of ability to treat, store or distribute water, 2) by creating a potential for a catastrophic release of on-site hazardous chemicals impacting the health of those in the community, 3) by theft of on-site chemicals, or 4) by adverse affects to public health and/or public confidence from intentional contamination.

Accidental spills, intentional terrorist attacks, vandalisms or contaminations from disgruntled employees could be played out on water systems by radioactive, biological or

chemical agents. Even though a threat to spread radioactive contamination over an area is serious, a threat to contaminate drinking water with it provides a larger challenge to a water system. The large quantity of radioactive material needed, its typical insolubility in water, and heaviness causing it to sink before reaching its target, are all factors to consider with this sort of threat (15). Biological threats can come in two kinds of agents: pathogens or toxins. Pathogens are living organisms including bacteria, parasites and viruses. Many bacteria and viruses are susceptible to disinfection products, while many others that can cause spores are totally resistant to disinfection with chlorine products. Toxins on the other hand are the poisonous substances produced by living organisms. The most toxic substance known to man is a toxin called botulinum toxin ("bo-tox"), and a small amount can be a lethal threat to a water system, enough to terrorize a population.

THE SAFE DRINKING WATER ACT

The Safe Drinking Water Act (SDWA) was established in 1974 to create major legislative authority for protecting public health by regulating the nation's drinking water supplies. The U.S. EPA, in partnership with state and local governments, is responsible for improving and protecting water quality in the more than 170,000 public water systems in the United States (45). States have the primary responsibility for the enforcement, monitoring, and reporting requirements of the drinking water standards. They also assess and protect drinking water sources (including wells and collection systems), enforce treatment of water by professional operators, provide support to distribution systems, and notify the public about the quality of their drinking water. The SDWA authorizes the U.S. EPA to award grants to states for developing and implementing programs to protect drinking water and groundwater sources (45).

The U.S. EPA sets national standards for drinking water based on sound science to protect against health risks, considering available technology and costs (45). They prioritize contaminants for regulation based on their risk factors and occurrence in water supplies, and then set a health goal based on that risk (including risk to sensitive people). The next step is to set a legal allowable limit for the contaminant or to standardize a treatment technique.

National Primary Drinking Water Regulations (NPDWRs), or primary standards, are legally enforceable standards that apply to public water systems, and are used as public water supplier standards to set the limits of contamination in drinking water (48). See Appendix A for list of NPDWRs. With the involvement of the U.S. EPA, states, tribes, and drinking water utilities set up multiple barriers to ensure that tap water in the United States and territories is safe to drink for communities and citizens. National Secondary Drinking Water Regulations (NSDWRs) are set for those substances which affect the aesthetic properties of water, and which have no affect on public health. See Appendix A for list of NSDWRs. Where as the NPDWSs are legally enforceable, the NSDWSs are merely suggested guidelines.

The NPDWRs set enforceable maximum contaminant levels (MCLs) for certain contaminants in drinking water, and establish required techniques to treat the water and remove the contaminants. The U.S. EPA uses a three-step process to set these standards. First, they identify the contaminants that may adversely affect public health and that frequently occur in drinking water at levels that could negatively affect health (45). Second, they establish a maximum contaminant level goal (MCLG) for those contaminants they determine need regulation (45). The U.S. EPA defines MCLG as “the

level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals" (48). Third, they establish MCLs, which is the maximum allowable level of the contaminant that can be delivered in the drinking water and is set as close to the MCLG as feasible (45). The U.S. EPA defines MCL as "the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards" (48). When there is no reliable or economic means to detect the regulated contaminants in the water, a treatment technique to remove them is established.

To prevent the contamination of drinking water, the SDWA has also established regulations to control for the injection of wastes into ground water. These regulations are collectively called the Underground Injection Control (UIC) program, and the U.S. EPA has placed the enforcement responsibility on the respective states (45). States are mandated to set standards for safe water injection practices and/or to ban certain types of injection altogether.

Additional Ground Water Regulations

The Resource Conservation and Recovery Act (RCRA) along with the Hazardous and Solid Waste Amendments of 1984 (HSWA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) are three predominant federal statutes, in addition to the SDWA, that provide legislation for the prevention of groundwater contamination. RCRA, mandated in 1976 to regulate the generation and transportation of hazardous waste, and to prevent future dumping of hazardous chemicals on land, contains major provisions that work to minimize groundwater contamination. It also regulates

conservation of existing dumps with inadequate storage in order to prevent further contamination from spills of hazardous waste. Specifically, Subtitle C of RCRA applies to waste management from industrial facilities and mandates that they must keep records and report on generators, transporters and disposers of hazardous waste on their site (37). RCRA does not have mandates for pesticides, deicing salts, or septic tank leachates, but the HWSA does regulate for underground storage tanks. FIFRA regulates for the use and disposal of pesticides. These statutes aid the SDWA in assuring quality drinking water while helping to protect public health.

Additional Surface Water Regulations

Federal regulations applicable to surface water systems require that these systems treat their water based on several regulations. These regulations are: the Surface Water Treatment Rule (SWTR), the Interim Enhanced Surface Water Treatment Rule (IESWTR), and the Stage I Disinfectants/ Disinfection Byproducts Rule (44). The SWTR was originated to prevent the spread of disease-causing, water borne microbes such as viruses, Legionella, and Giardia lambila, which occur at different concentrations in most surface waters (43). It contains provisions that require disinfection and filtration for all public water systems (PWS) that use surface water (or a source that is ground water under the direct influence of surface water), to provide a minimum of 99.9% combined removal and inactivation of Giardia and 99.99% of viruses (48). The rule established MCLs for turbidity, bacterial plate counts, *Giardia Lamblia* cysts, Legionella, and enteric viruses. The SWTR also published approved testing methodologies for the purpose of determining compliance. The IESWTR amends the SWTR and applies to water systems that serve 10,000 people or more. It helps develop a rule to strengthen

protection against the *Cryptosporidium* bacteria, which is resistant to traditional disinfection (chlorination). Lastly the Stage 1 Disinfection Byproducts Rule applies to those water systems that need to add a disinfectant to a part of their treatment process.

WATER TREATMENT FACILITIES

The treatment process to prepare drinking water depends primarily on the water that is being treated, the source it is taken from, and the quality of the source water. Public health is the primary goal of water treatment. Therefore water treatment and purification of raw water involves the removal of chemicals and microorganisms, in addition to making it aesthetically acceptable for color, taste and odor (30).

Drinking water systems are at risk for terrorism since the product that they distribute is ingested. There is obvious potential for casualties (possibly in large numbers) because drinking water is a basic necessity for life, and the availability of public water is industrially and economically important. The potential for attacks is high due to several factors: 1) drinking water is typically distributed over a large geographic area; 2) the facilities contain many components which could be compromised; 3) there is an association with the state or government system; and 4) the advancement of technology which makes more processes automated, makes them more prone to electronic breakdown.

There are some deterring factors that a terrorist may reconsider before trying to contaminate a system: the dilution factor (would take a large quantity of a substance to affect a system); water treatment may be very effective in removing many agents; and the chlorine residual maintained in most distribution systems may be enough to protect against some (but not all) microbial and chemical contaminants. Distribution systems are

vulnerable through 1) contamination with chemical, biological, or radiological contaminants, 2) contamination threats which can disrupt operation at a system, or 3) an interruption of electricity to pumps or treatment systems which could give a terrorist an opportunity to contaminate a system.

PWSs, either publicly or privately owned, vary in size depending on the size of the population served, and also on the type of water used. They must meet a minimum of standards to be in operation and these include: having at least 15 service connections and/or serving at least 25 people per day for 60 days of the year (44). The two categories of PWSs that are commonly seen are the Community Water System (CWS) and the Non-Community Water System (NCWS). The CWS serves the same group of people year round; those include people in residences in cities and small towns. The NCWS serves the public but not the same group year round. This category is broken up into the Non-Transient Non-Community Water System, which serves the same group but not year round (i.e., a school with it's own water supply), and the Transient Non-Community Water System, which does not serve the same group of individuals for more than six months (i.e., a campground) (44).

Groundwater

Groundwater comprises 96% of all the freshwater in the United States. In Louisiana there are 1,612 water systems, serving 3,009,656 people that use ground water as their source of drinking water. The U.S. EPA reports that ground water provides to the United States:

22% of all freshwater withdrawals,

34% of all agricultural use (mainly for irrigation purposes),

40% of the public water supply withdrawals,

53% of all drinking water for the total population,

97% of drinking water for the rural population (46).

While it is found to have high mineral content (calcium and magnesium), high salinity, and high total dissolved solids because of its reaction with geological material, it is usually devoid of bacteria and particulate organic matter (30). It should be characterized by clarity, bacterial purity, constant temperature and chemical quality (35). Fortunately for the PWS, it can usually satisfy all Federal requirements without applying any treatment (Louisiana has over 100 transient non-community water systems which have no disinfection processes). In Louisiana, as in other states, groundwater from wells, aquifers, or springs can become contaminated with toxic chemicals through the incorrect handling and disposal of hazardous chemicals (30). These systems would need to add chlorine or apply other treatment techniques to satisfy regulations for purposes of drinking. Untreated groundwater may also be unfit for certain industrial uses because of its higher mineral content and affinity for causing scaling in boiler systems.

Surface Water

Surface water, including streams, lakes, reservoirs, or rivers, comprises 4% of the fresh water in the United States. In Louisiana there are 84 systems serving 1,996,141 people, that use surface water as their source of drinking water. Water supplies serving large populations typically are surface water sources, and those serving smaller populations are typically groundwater sources (44). Typically surface water requires

more involved treatment than groundwater due to the larger array of contaminants found in the water. These sources are exposed to wet weather runoff and the atmosphere, and can become contaminated with sewage wastes and fecal coliforms, suspended soil particulates, bacteria, and various chemicals like fertilizers.

Water Treatment Processes

General characteristics of water systems include a surface or ground water source, a transmission system including tunnels, reservoirs, pumping stations and storage facilities, and a distribution system to carry the finished potable water to consumers (15). The source where water is taken from plays an important role in the amount of treatment needed for potability. Water that is potable is devoid of bacteriological components and it contains a residual disinfection component. Through a process called clarification, which involves coagulation-flocculation, sedimentation and filtration, along with a disinfection procedure (usually chlorination), water is treated for potability (See Figure 1) (30). More advanced techniques include ion exchange and adsorption.

Coagulation-Flocculation: Coagulation is a process in which chemicals such as alum, or other polymers, are added to the water to agglomerate with colloids, which would not settle out of suspension by gravity without some help. The coagulant chemicals neutralize the charges found on colloids and allow them to stick together to form bigger, heavier particles called “floc” (30). Flocculation is the agitation of the mixture which increases the collisions between colloids to form floc (30). Most of the flocs formed during this procedure will settle out and can be removed through the next process, sedimentation.

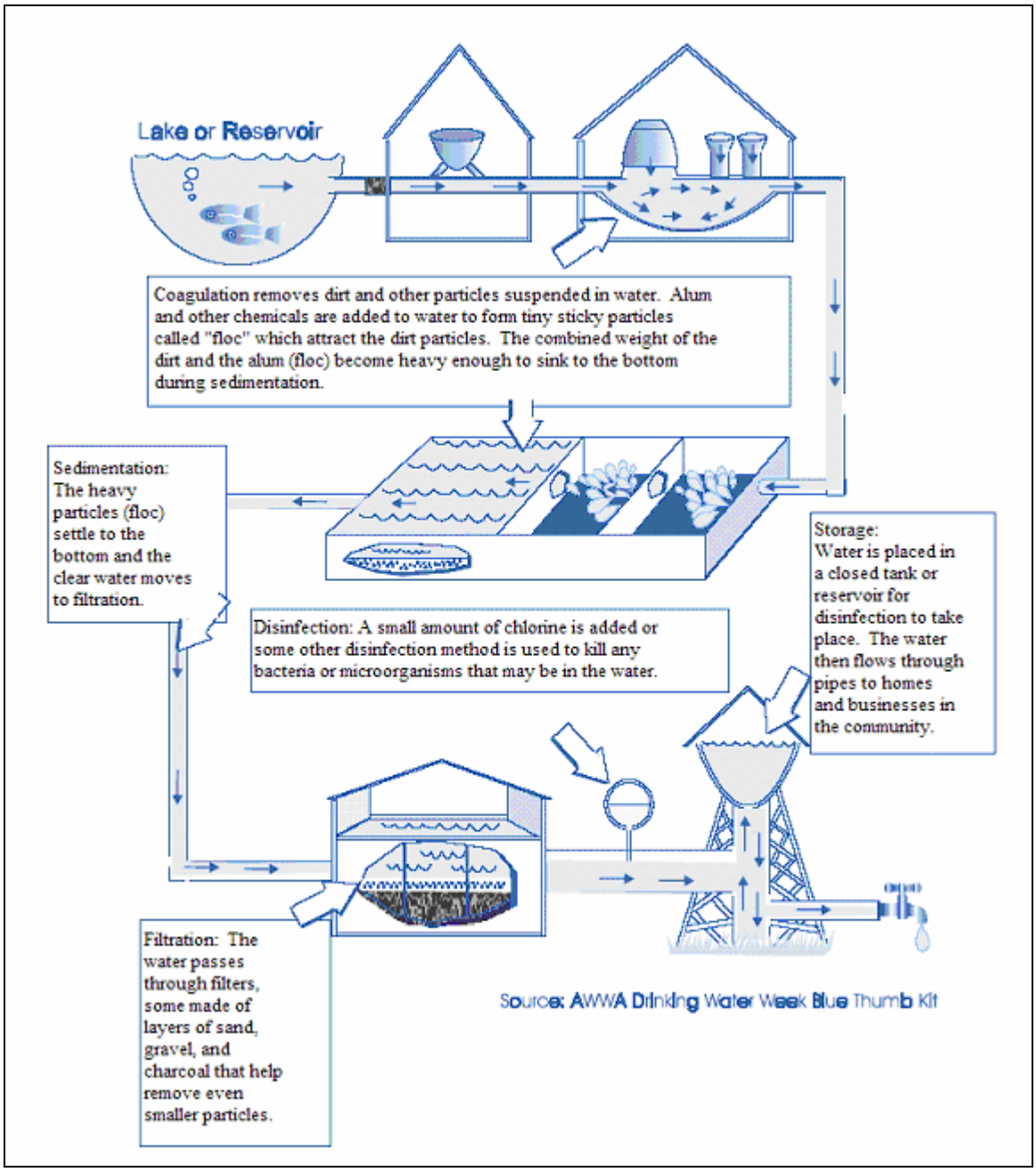


Figure 1. Flow Diagram of a Surface-Water Treatment Plant (Adapted from EPA 810-F-99-013 {3})

Sedimentation: Sedimentation allows the heavier particles from coagulation to settle to the bottom of a sedimentation or settling tank. Particle size, as well as temperature and

viscosity of the water are all factors that affect particle-settling rate (30). It is not feasible to leave a volume of water undisturbed in a tank to allow the particles to settle out. Generally, the water only stays in the settling tank for a few hours before it reaches the tank outlet and the clear water is passed along to the next step, filtration. Most settling tanks are designed with a well designed sludge scraper mechanism that pushes the settled sludge into a hopper for later removal, and prevents currents that could resuspend the sludge.

Filtration: Typically about 5 percent of the suspended particulates from the sedimentation tank will remain in the water column and not settle out (30). These particles cause water turbidity and still allow microorganisms a place to cling onto. Most filtration systems use a myriad of methods to remove all remaining particles from the water. Remaining particles generally include clays and silts, natural organic matter, precipitates and microorganisms. Therefore, a permeable fabric or porous granular filter media such as sand is often used and is set up with a size distribution of filter material in a larger-to-smaller particle graduation (30). Several materials are needed in this process to ensure all particles are removed, and most commonly gravel, sand and charcoal are used.

Disinfection: Disinfection is necessary for public health to ensure that all pathogenic bacteria or viruses are removed (which the three other processes would have not been able to remove) from the water before it is distributed. Chlorine is the most commonly used because of its effectiveness in disinfection not only at the treatment plant but also for the pipes that distribute the water (44). Chlorination is also the most important for preventing the spread of disease. It does not come without its problems though. Most

natural waters contain organic compounds which react with the chlorine to indirectly produce compounds called trihalomethanes (THM), which are found to be carcinogenic.

Other Processes: Other disinfection processes include ozonation and ultraviolet radiation. Using ozone to treat water is advantageous in that it is a strong oxidizer and requires short reaction time to kill germs and viruses in the water while providing oxygen to the water with no use of extra chemicals. Yet it has limitations too in that it is more costly than chlorine and it does not control biological contaminants in the pipes that distribute the water, therefore postchlorination is required (28). Ultraviolet radiation is useful in that it is generated by a special lamp which can penetrate the cell wall of an organism and disrupt its reproduction. It can effectively destroy bacteria and viruses, but may not destroy Giardia or Cryptosporidium cysts. As with ozone, a postchlorination is required and it can be a costly application to keep the UV lamp and reactor in working order.

Ion exchange is a process used to rid filtered water of inorganic contaminants if they cannot be removed by any other of the treatment processes (44). In systems that have hard water, ion exchange can help to remove the calcium and magnesium buildup, and water demineralization. Adsorption is another process to remove aesthetic unpleasantries such as color or taste problems, as well as removing any extra organic compounds. This process uses powder activated carbon to stick to the surface of contaminants to then be removed.

SEVERN TRENT AND ECLOX-M™

The threat of a terrorist attack and its resulting devastating consequences on our nation led the Bioterrorism Preparedness and Emergency Response Division, in June

2002, to award the SDWP grant monies to purchase necessary equipment to conduct analysis and assessments on suspected contaminated waters. Most lab analyses for terrorism incidences are targeted to measure exact concentrations of chemicals or specific counts of microorganisms. Since terrorists can use a wide variety of chemical substances to infect a water supply, there was need for a broad range test that could rapidly indicate the existence of contamination in both raw and finished water. The test needed to be accurate, easy to use in the field, robust, and which performed a rapid screening of water quality.

The SDWP had only a two week period in which they had to use the grant monies and purchase a surveillance system. Therefore, knowing the reputation of Severn Trent Services to produce quality products, and its ability to get U.S. EPA Environmental Technology Verification (ETV) for its ECLOX-M™ system, the state quickly invested the monies into their surveillance system to exercise due diligence – being proactive in minimizing vulnerabilities and preventing attacks. The SDWP purchased twelve ECLOX-M™ units from Severn Trent; one for each of its nine regions, two for OPH Central Labs and one specifically for the SDWP Headquarters. The purchase was based on the fact that the ECLOX-M™ had already been used in Utah for the 2002 Winter Olympics, and the Utah SDWP was very satisfied with the performance of the machine. Louisiana's SDWP was not required to use a competitive process for choosing the system, because at the time that they were ordered, the technology was unique in the marketplace. Therefore no other surveillance systems were considered, as no other system offered anywhere near as many screening possibilities. The ECLOX-M™ was the only system that could produce rapid detection of contaminated water, that could be a

reliable indicator of relative water quality, and that was easy to use with minimum training.

Severn Trent Services, a subsidiary of Severn Trent Plc of Birmingham, England, is a company based out of Fort Washington, PA, which offers drinking water and wastewater treatment solutions. Their main focus is to supply a broad range of products and services for disinfection and filtration technologies, pipeline analysis, rehabilitation and repair services. Their products and services have been verified for performance through the U.S. EPA ETV Program. This program protects the environment by testing cost-effective technologies for the environment through peer-reviewed data and technology performance, for acceptance, and use by those in the industry (23).

Technology Description

The ECLOX-M™ Test Kit is in use by the UK armed forces as a broadband test that qualitatively assesses a water sample to verify whether it has been contaminated. It is an easy to use, self contained, portable unit which allows for analysis of water while out in the field, with the capability of downloadable data for record keeping. The system was initially used for military technicians to perform tests on raw water to determine if it was suitable for consumption. The simplicity and speed of the testing and analysis has made it attractive to states and water utility systems to use in the event of intentional contamination.

Chemiluminescence Test

The system works with a luminometer which gives a rapid and generic identification of the contamination of water with the use of a chemiluminescence technique. Chemiluminescence is simply the production of light as a result of a chemical

reaction. The ECLOX-M™ system uses this phenomenon to measure toxicity in water by integration of the water sample with a mixture of luminol or 3-aminophthalhydrazide, ($C_8H_7O_3N_3$), and an oxidant in the presence of a catalyst enzyme – horseradish peroxidase (HRP). The use of a plant enzyme to produce light output creates an effect called enhanced chemiluminescence. Although Severn Trent does not report the oxidant or enhancer chemical used, Jain *et al.* (2004) reports from similar studies, that luminol was used with p-iodophenol and H_2O_2 to produce enhanced chemiluminescence with HRP (22). The p-iodophenol acts as an oxidant enhancer for the reaction in their experiments. Tsukagoshi *et al.* (2002) report that the effect of p-iodophenol as an enhancer of luminol chemiluminescence can intensify the chemiluminescence of luminol by two orders of magnitude higher than that in the unenhanced reaction (40). The enhancer ensures that light output is steady at a measurable level. The luminol and enhancer are the principle players in the chemical reaction, but in order to produce a strong glow, they need a catalyst, HRP, to accelerate the process

The reaction between the water sample and these chemicals produce a flash of light which is measured by the luminometer. A measure of relative toxicity is shown on the LCD screen of the ECLOX-M™ as a percentage of light inhibition. The light produced from the reaction is indirectly proportional to the amount of contaminant in the water sample, as the contaminant will interfere with the reaction (generally the amount of light generated decreases as the concentration of contaminant increases). After a test is run, the results are then compared to the baseline sample that was run first with a contaminant-free reference - deionized water - which gives a high light output (due to the toxic free nature of the water).

This technology does not identify or determine the concentration of a specific contaminant, but it is merely used as a generic qualitative field test to determine water quality and toxicity. The chemiluminescence test has the capability of detecting substances with different modes of toxic action such as polar narcotics, respiratory blockers, oxidative uncouplers, membrane irritants, cholinesterase inhibitors, CNS convulsants, heavy metals, photosynthetic inhibitors, and cell division inhibitors. Appendix B contains Severn Trent's response to substances with different modes of toxic action and limits of detection for the chemiluminescence test. The chemiluminescence test also has the capability of testing both freshwater and salt water. It is noted that free radical scavengers or antioxidants, and substances such as phenols, amines or heavy metals can interfere with the reagent reactions and reduce light emission (23).

Additional Quality Assurance Tests

The test system includes the equipment for seven standard tests which are suggested to be run with every sample. These tests are for arsenic, pesticides/nerve agents, mustard gas, chlorine content, color, total dissolved solids (TDS), and pH. Pesticide/nerve agent and mustard gas test strips are available as an option with the kit, and are purchased separately. The Louisiana SDWP has purchased pesticide/nerve agent test strips for all of its units, but not those for mustard gas.

Arsenic: Arsenic is a poison and a toxic industrial pollutant which can also be found in some chemical warfare agents such as Lewisite. Test strips are provided in the kit which will change the color of the reaction zone for a positive result. Positive results are compared to a color chart to determine the range of contamination.

Pesticide/Nerve Agent: The pesticide/nerve agent test is less specific and will show a white disk for a positive (YES), and a blue disk for a negative (NO) reading. See Appendix C for Severn Trent Pesticide Test Strip Detection Limits.

Chlorine: Chlorine is used in the disinfection treatment processes of many drinking water facilities to destroy many bacterial elements that may be found in the water. The chlorine test here checks how much free chlorine is present in the sample water and gives a result in mg/L based on a color comparison.

Color: Water can be naturally colored due to natural minerals and metals in the water in addition to other natural run off processes. The color test is a comparison test which compares the water sample to a color chart.

TDS: TDS is closely related to the conductivity of the water. This test measures the amount of dissolved solids using an electronic meter which gives results in $\mu S/cm^3$.

pH: pH level is measured with a pH meter that is calibrated at a pH of 6.9 with a calibrating solution.

All of these tests can help an operator determine the appropriate action to take on a water system according to the contamination level from the test results. The tests can be used out in the field to compare and rank possible waters which would be best for purification and for drinking, in a possible military situation. Severn Trent states that the system can also be used as a regular quality assurance test on treated drinking water produced, or on source water (38).

Other Broad Range Toxicity Testing Systems

Most other rapid toxicity technologies use bacteria, enzymes, or small crustaceans that can react with reagents either directly or in combinations to produce flashes of light

when contaminants are in the water (23). The Microtox system, designed by Strategic Diagnostics, Inc, of Newark, Delaware, is also a broad range screening assay, yet is more complicated to use than the ECLOX-M™ system. The system has both a field version and a laboratory version for versatility. The system is based on an acute toxicity bioassay which employs the use of the luminescent bacteria, *Vibrio fischeri*, to conduct a bacterial bioluminescence test. Typically luminescent bacteria use up to 10% of their respiratory energy for specific metabolic pathways that convert chemical energy into light. When there is a change in the respiratory pattern of cells, or a disruption in cell structure, one can see a resulting change in bioluminescence. At a concentration of 10^6, the *Vibrio* bacteria are added to the water samples and the light output of the test bacteria is recorded with a laboratory photometer. As is with the ECLOX-M™, if an acutely toxic substance is present in the water sample, a measurable decrease in light output will be seen. The reduction of light is proportional to the impact of the contamination in the water sample.

CHEMICAL AGENT EFFECTS ON DRINKING WATER SYSTEMS

Chemicals can enter and contaminate drinking water systems through several means including surface runoff, leaching from toxic waste dumps, leaking underground storage tanks, or through malevolent acts. Although much is known about chemical agents and their dispersion through the air, less is known about how they are dispersed in water. Clark *et al.* (2000) states that the amount of material needed to contaminate a water source might be large and exceed what an individual or group of terrorists might be able to acquire (12). Thus it may be safe to say that contaminating a raw water source is not attractive due to 1) the large volume of the source, 2) much of the material may be

wasted by flow past water works intakes, 3) the opportunity for finding unsecured sites are few, and finally 4) the treatment plant would reduce the concentration and detect abnormal aspects of the water (8). Introducing chemicals into a distribution system however would make them less susceptible to dilution and they would reside in the system for shorter times with less exposure to disinfectants or chemical decomposers. Substantial amounts of chemicals could be pumped directly into a distribution system using available commercial equipment.

According to the DHS, there are roughly six classes of chemical contaminants that cause the biggest threats to the public drinking water system. These include nerve agents/pesticides (i.e., sarin, VX, atrazine, carbofuran), blister agents (i.e., phosgene, mustard gas, lewisite), cyanides (via their suffocation ability and inhibitory effect on a cell to absorb oxygen), choking agents (i.e., chlorine gas, phosgene), irritants (i.e., tear gas), and toxic industrial chemicals (i.e., heavy metals, vinyl chloride, trichloroethylene, ammonium hydroxide) (15). The ECLOX-M™ system is capable of detecting most of these chemicals and can group them according to their mode of action.

Based on their ease of use, ability to be unobtrusively obtained or produced, and accessibility for this project, chemical standards in two classes were tested: toxic industrial chemicals and nerve agents/pesticides. Three chemicals in the toxic industrial chemicals class were evaluated (mercury, a volatile liquid mixture, and a volatile gas mixture), and two chemicals in the nerve agents/pesticide class were evaluated (atrazine and a regulated pesticide mixture of carbamate pesticides). Chemical components for the chemical mixtures are listed in Table 1.

Table 1. Components of Chemical Standard Mixtures

Volatile Liquid Mixture

Benzene	1,3-Dichlorobenzene	Napthalene
Bromobenzene	1,4-Dichlorobenzene	*n*-Propylbenzene
Bromochloromethane	1,1-Dichloroethane	Styrene
Bromodichloromethane	1,2-Dichloroethane	1,1,1,2-Tetrachloroethane
Bromoform	1,1-Dichlorothene	1,1,2,2-Tetrachloroethane
n-Butylbenzene	*cis*-1,2-Dichloroethane	Tetrachloroethane
Sec-Butylbenzene	*trans*-1,2 Dichloroethane	Toluene
Tert-Butylbenzene	1,2-Dichloropropane	1,2,3-Trichlorobenzene
Carbon tetrachloride	1,3-Dichloropropane	1,2,4-Trichloroebenzene
Chlorobenzene	2,2-Dichloropropane	1,1,1-Trichloroethane
Chloroform	1,1-Dichloropropene	1,1,2-Trichloroethane
2-Chlorotoluene	*cis*-1,3-Dichloropropene *	Trichloroethene
4-Chlorotoluene	*trans*-1,3-Dichloropropene **	1,2,3-Trichloropropane
Dibromochloromethane	Ethylbenzene	1,2,4-Trimethylbenzene
1,2-Dibromo-3-chloropropane	Hexachlorobutadiene	1,3,5-Trimethylbenzene
1,2-Dibromoethane	Isopropylbenzene (*Cumene*)	*o*-Xylene
Dibromoethane	*p*-Isopropyltoluene (*p-Cymene)*	*m*-Xylene
1,2-Dichlorobenzne	Methylene chloride	*p*-Xylene

Volatile Gas Mixture

Bromomethane	Chloromethane	Trichlorofluoromethane
Chloroethane	Dichlorodifluoromethane	Vinyl chloride

Regulated Pesticide Mixture

Aldicarb	Carbaryl	Methomyl
Aldicarb sulfone	Carbofuran	Oxamyl
Aldicarb sulfoxide	3-Hydrocarbofuran	

* (1.06 x conc.)
** (0.94 x conc.)

The Agency for Toxic Substances and Disease Registry (ATSDR) 2003 CERCLA Priority List of Hazardous Substances ranks the majority of these types of chemicals in the top 25 most hazardous substances (See Table 2). The priority list is a prioritization of substances based on the combination of their frequency found in the environment, toxicity, and potential for human exposure (5).

Important in-house testing can be conducted by a water facility in response to a threat or for routine monitoring in a state of heightened national security. Standard analyses include tests for cyanide, volatile organic compounds, trace metals, total organic carbon, pH, alkalinity, TDS, and bacterial cultures (coliform and plate counts) (15). These analyses are usually carried out by equipment such as gas chromatography, atomic absorption spectrophotometry, and heterotrophic plate count cultures (15). Yet nonspecific information on the presence of contaminants in the water can be rapidly screened by commercially available acute toxicity screening tests such as the ECLOX-M™ or Microtox.

Table 2. ATSDR 2003 CERCLA Priority List of Hazardous Substances – Top 25 Chemicals

2003 RANK	SUBSTANCE NAME	TOTAL POINTS
1	ARSENIC	1663.11
2	LEAD	1531.60
3	MERCURY	1506.66
4	VINYL CHLORIDE	1385.32
5	POLYCHLORINATED BIPHENYLS	1372.92
6	BENZENE	1356.30
7	CADMIUM	1319.32
8	POLYCYCLIC AROMATIC HYDROCARBONS	1317.54
9	BENZO(A)PYRENE	1308.71
10	BENZO(B)FLUORANTHENE	1265.26
11	CHLOROFORM	1228.08
12	DDT, P,P'-	1191.57
13	AROCLOR 1254	1186.98
14	AROCLOR 1260	1176.90
15	DIBENZO(A,H)ANTHRACENE	1163.45
16	TRICHLOROETHYLENE	1161.43
17	CHROMIUM, HEXAVALENT	1151.98
18	DIELDRIN	1148.09
19	PHOSPHORUS, WHITE	1144.87

(Table 2 continued)

20	CHLORDANE	1130.53
21	DDE, P,P'-	1130.20
22	HEXACHLOROBUTADIENE	1129.10
23	COAL TAR CREOSOTE	1124.66
24	DDD, P,P'-	1117.38
25	BENZIDINE	1114.82

(Adapted from the ATSDR 2003 CERCLA Priority List of Hazardous Substances).

The chemicals tested in this project were evaluated for the following parameters: physical and chemical properties; common uses; amount produced in Louisiana from industry; amount released to the environment; resulting toxicity, contamination potential and exposure. The US EPA reports the MCL levels for several of the chemicals evaluated in this study (See Table 3). Knowing that industry releases the chemicals to the environment, this is their means to regulate the amounts found in ground or surface water supplies as background levels. Spikes in these levels would suggest possible contamination.

Table 3. List of Chemicals, and Those Contained in Mixtures, Used in This Study with their MCLs

Number	**Contaminant**	**MCLG mg/L)**	**MCL (mg/L)**	**Potential health effects from exposure**	**Common sources of contaminants in drinking water**
1	Mercury (inorganic)	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland
2	Atrazine	0.003	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops
3	Benzene	Zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills

(Table 3 continued)

4	Chlorobezene	0.1	0.1	Liver or kidney problems	Discharge from chemical or agricultural chemical factories
5	1,2-Dibromo-3-chloropropane	Zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
6	1,2-Dichloroethane	Zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
7	Ethylbenzene	0.7	0.7	Liver or kidney problems	Discharge from petroleum refineries
8	Oxamyl	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
9	Styrene	0.1	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills
10	Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
11	1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
12	1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
13	1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
14	Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
15	Carbofuran	0.04	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa
16	Vinyl chloride	Zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
17	Trichloroethylene	Zero	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories
18	Carbon tetrachloride	Zero	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities

(Adapted from U.S. EPA NPDWRs list, www.epa.gov/safewater/mcl.html)

TOXIC INDUSTRIAL CHEMICALS

Toxic industrial chemicals are those chemicals used in manufacturing, processing, and industrial cleaning and are considered deadly when they enter into drinking water. They are typically less toxic than chemical warfare agents, but are more readily available and can be easily obtained by terrorists (15). Louisiana has several cities that are considered major ports and hubs for chemical industry in the south. This ranks the state high as a target for terrorism and/or chemical disasters due to the availability of chemicals present.

Volatile Liquid Mixture

A volatile liquid mixture standard was made available for testing which included 54 different toxic industrial components (See Table 1). Three of these volatile liquids are of particular importance in Louisiana's chemical industry (Benzene, Carbon Tetrachloride, and Trichloroethylene) and they are good representatives of this chemical category. Louisiana as a state, ranks high in the nation for amounts produced and released.

Benzene:

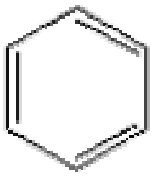


Figure 2. Schematic of Benzene (Adapted from www.chemfinder.com)

Physical and Chemical Properties**:** Benzene (C_6H_6) is a clear, colorless aromatic liquid with a molecular weight of 78.11 g/mol (50). It evaporates into the air very quickly, is

highly flammable and only dissolves in water slightly, 0.18 g/100 mL. It has a sweet odor and can be smelled in the air at 1.5-4.7 ppm and smelled in the water at 2 ppm.

Common Uses: Benzene is produced in the United States by petrochemical and petroleum industries because the chemical can be recovered from both coal and petroleum sources (36). Benzene is used as a building block for making plastics, rubber, resins and synthetic fabrics like nylon and polyester. It acts as a solvent for many chemicals in the chemical industry and has importance in gasoline additives (31). It is important in unleaded gasoline for its anti-knock capabilities, therefore the concentration found in fuels has increased to 1-2% (34).

The U.S. EPA has listed benzene as a hazardous air pollutant and hazardous waste, therefore widespread use of benzene has diminished over the years (42). Leakage from underground storage tanks or from landfills or hazardous waste sites can result in contamination of wells and/or ground water.

Amounts Produced/Released: The ATSDR reports that benzene was the 17th highest volume chemical produced in the United States with 14.7 billion pounds produced in 1994 (24). The U.S. has 27 companies producing benzene and 48 facilities within LA that produce the chemical.

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of benzene in the state of Louisiana were 644,896 pounds for both on and off-site releases: 558,257 pounds to the atmosphere, 873 pounds to surface waters, 1,164 pounds to land, and 81,341 pounds to underground injection (47). The Environmental Defense Fund Scorecard 2001 statistics rank Louisiana second in total reported environmental releases for benzene among the other states and territories (41).

The top three facilities, out of 48 for the state, responsible for the total environmental releases are Safety-Kleen Inc. located in Plaquemine, Citgo Petroleum Corp. located in Lake Charles, and Chalmette Refining L.L.C, located in Chalmette respectively (41).

Toxicity and Exposure*:* Reports of toxic effects in humans have that inhalation is the primary route of absorption in the body, with ingestion and drinking contaminated water as secondary routes (1). Respiratory effects including mucous membrane irritation have been reported in humans after acute exposure. Chronic exposure can result in drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and at high levels even death (1). Ingestion of contaminated food or water can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, or even death.

The Department of Health and Human Services has determined benzene to be a known carcinogen with long term exposure causing cancer of the blood forming organs, or leukemia (1). Hricko (1994) reports that there is strong evidence of increased risk for acute myeloid leukemia at high levels of exposure but there is only limited information about toxic effects at current exposure levels in the U.S. (20). Benzene harms the bone marrow and causes anemias from a decrease in red blood cells. Also it can cause excessive bleeding and can affect the immune system. Studies on women have shown that after breathing in high levels of benzene they experienced irregular menstral periods and had a decrease in the size of their ovaries. No information has confirmed adverse effects of developmental toxicity on fetuses in pregnant women, nor fertility affects in men to benzene exposure (1).

Carbon Tetrachloride:

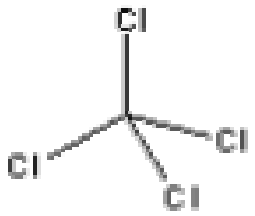


Figure 3. Schematic of Carbon Tetrachloride (Adapted from www.chemfinder.com)

Physical and Chemical Properties: Carbon Tetrachloride (CCl_4) is a clear heavy organic liquid with a molecular weight of 153.82 g/mol. It has a sweet aromatic odor close to that of chloroform. It is almost insoluble in water (water solubility of 800 mg/L at 20ºC) but it is miscible in organic solvents (7). Due to its nonflammable nature, it is in a group of hydrocarbons called the alkyl halides which are effective extinguishing agents. CCl_4 moves quickly into the air upon release and it evaporates quickly in surface water. It also does not stick to soil easily and is easily broken down, so it either evaporates or moves to the ground water (7). Synonyms and registered trade names include perchloromethane, methane tetrachloride, and benzinoform.

Common Uses: Carbon Tetrachloride is currently used as a solvent for oils, fats, lacquer, varnishes, rubber waxes and resins, and as a starting material in the manufacture of organic compounds and chlorofluorocarbons (7). Formerly it was used as a dry cleaning agent, a grain fumigant and pesticide, in the production of refrigeration fluid and propellants for aerosol cans, in fire extinguishers and in spot removers (7). It is now banned for these uses and only used in some industrial applications, due to an international agreement (Montreal Protocol) to reduce ozone-depleting chemicals.

Amounts Produced/Released: In 2002 Carbon Tetrachloride was manufactured in the U.S. at only one company, Vulcan Materials Company located in two cities: Geismar, LA, and Wichita, KS (7). The Louisiana plant produces the chemical at a 90 million pound annual capacity.

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of carbon tetrachloride in the state of Louisiana were 200,478 pounds for both on and off-site releases: 98,130 pounds to the atmosphere, 39 pounds to surface waters, 5,929 pounds to land, and 95,935 pounds to underground injection (47). The Environmental Defense Fund Scorecard 2001 statistics rank Louisiana first in total reported environmental releases for carbon tetrachloride among the other states and territories (41). The top three facilities, out of 12 for the state, responsible for the total environmental releases are Safety-Kleen Inc. located in Plaquemine, LA, Rubicon, Inc. located in Geismar, LA, and Vulcan Materials Co. Chemicals Div. located in Geismar, LA, respectively (41).

Toxicity and Exposure: CCl4 is found to target several major organs in the human body. The liver is most sensitive and exposure can cause enlargement and cellular damage (7). The kidneys can lose function and start to build up wastes in the blood stream upon exposure. It can also effect the brain and nervous system to make one feel intoxicated, experience headaches, dizziness, sleepiness, nausea, vomiting and in severe cases coma and/or death (7). The International Agency for Research on Cancer (IARC) has not determined carcinogenicity on carbon tetrachloride (21). Exposure comes from breathing in contaminated air near manufacturing plants or waste sites, and from drinking contaminated water.

Trichloroethylene:

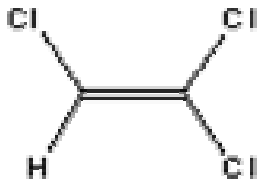


Figure 4. Schematic of Trichloroethylene (Adapted from www.chemfinder.com)

Physical and Chemical Properties: Trichloroethylene, (C_2HCl_3), or TCE, is a clear colorless liquid at room temperature with a molecular weight of 131.39 g/mol (54). It is an alkyl halide which is slightly water soluble (water solubility at 25ºC is 1.366 g/L), and is miscible with many organic solvents. Since TCE does not occur naturally in the environment, it enters into the air during use and transport, and when released to the soil it either evaporates or leaches into the groundwater (14). It does not bind well to soil and can be broken down by oxidating enzymes. Therefore, it is not often found on the bottoms of rivers or lakes (33). Registered trade names include trichloran, and chlorilen.

Common Uses: TCE is primarily used as a solvent to remove grease from metal parts (54). It can be used both as a solvent or a component of other solvent blends to be included in adhesives, lubricants, paints, varnishes, paint strippers, carpet shampoos and waterproofing agents. Many chemical industries use it in the production of polyvinyl chloride where it acts as a chain transfer agent, yet it can also be used in the production of pharmaceuticals, polychlorinated aliphatics, flame retardants, and insecticides (27). In 1977 the U.S. Food and Drug Administration (USFDA) banned its use as an additive in food substances and for the extraction of caffeine from beverages (2).

Amounts Produced/Released: The ATSDR reports from 1987 data that there are only two U.S. manufacturers of TCE (2). The two manufacturers are DOW Chemical in Freeport, Texas, and PPG Industries in Lake Charles, LA. The ATSDR reports that these two manufacturers have an annual production of 320 million pounds combined (2). There are twelve facilities located in Louisiana.

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of trichloroethylene in the state of Louisiana were 152,110 pounds for both on and off-site releases: 53,327 pounds to the atmosphere, 72 pounds to surface waters, 403 pounds to land, and 98,220 pounds to underground injection (47). The Environmental Defense Fund Scorecard 2001 statistics evaluate the state of Louisiana as ranked 19th in total reported environmental releases for trichloroethylene among the other states and territories (41). The three top facilities in the state responsible for the total environmental releases of trichloroethylene, respectively, are Safety-Kleen Inc. located in Plaquemine, Gulf Wire Corp. located in New Orleans, and PPG Industrial Inc. located in Lake Charles (41).

Toxicity and Exposure: Sources of emissions and exposures come from shipping terminals during the handling of imported TCE from rubber manufacturers, iron and steel manufacturers, and manufacturers of paints, inks, varnishes and lacquers. TCE targets the CNS, liver, kidneys, heart and lungs. It has been classified as a central nervous system (CNS) depressant, and upon exposure can cause headaches, dizziness, loss of balance, and tremors (10). Inhalation exposure can cause a burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and vomiting (10). Inhalation is the most common form of exposure and high concentrations can be

destructive to the tissues of the lungs and mucous membranes of the upper respiratory tract. Paternal effects such as spermatogenesis and effects on fertility can occur in exposed persons, as well as developmental abnormalities in the fetus (10). The National Occupational Health and Safety Commission (NOHSC) classifies TCE as a Category 2 carcinogen (regarded as if carcinogenic to humans) with a human –oral LDL_o of 7 g/kg.

Volatile Gas Mixture

The volatile gas mixture standard made available included 6 gas components (See Table 1). Vinyl chloride, one of the components, is of particular importance to the chemical and plastics industry in Louisiana.

Vinyl Chloride:

Figure 5. Schematic of Vinyl Chloride (Adapted from www.chemfinder.com)

Physical and Chemical Properties: Vinyl Chloride (C_2H_3Cl) (also known as chloroethene) has a molecular weight of 62.50 g/mol. It is a flammable colorless gas that has a slightly sweetish odor and becomes explosive when exposed to heat or flame (32). It is slightly water soluble (water solubility at 25ºC is 2,763 mg/L), and a great organic solvent which is soluble in hydrocarbons, oil, alcohol, and chlorinated solvents.

Common Uses: Vinyl Chloride is an organic gas used widely for the production of plastics including building and construction materials, automotive parts, cable and wire insulation, medical supplies, and both industrial and household equipment. It is also used extensively in chemical, rubber, paper and glass industries (55). The chemical is produced in large quantities in Louisiana and used almost exclusively for polyvinyl

chloride (PVC) production as well as for other polymers (19). PVC is used to make a variety of plastic products including pipes, wire and cable coatings, and packaging materials.

Amounts Produced/Released: The most current U.S. ATSDR vinyl chloride production data, reports that 14.98 billion pounds were produced in 1995; an increase of 8% over 1994 production (3). The ATSDR have identified that vinyl chloride is produced by 10 companies at 12 facilities in the U.S. Six of the companies are based in Louisiana and they are: Borden Chemicals and Plastics, DOW Chemical, Georgia Gulf Corp., PPG Industries, Vista Chemical Corp., and Formosa Plastics Corp.(3).

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of vinyl chloride in the state of Louisiana were 203,995 pounds for both on and off-site releases: 107,921 pounds to the atmosphere, 9 pounds to surface waters, 0 pounds to land, and 96,023 pounds to underground injection (47). The Environmental Defense Fund Scorecards 2001 statistics rank the state of Louisiana second in total reported environmental releases for vinyl chloride among the other states and territories (41). Safety-Kleen Inc. and Georgia Gulf Chemicals & Vinyls LLC, both located in Plaquemine, LA rank first and second, respectively, and Borden Chemicals & Plastics Operating LP located in Geismer and Addis, LA rank third and fourth, in terms of facilities reporting environmental releases of vinyl chloride (41).

The majority of releases to the environment come from manufacturer's facilities in accidental releases and in their wastewater streams (14). We also see releases of vinyl chloride in drinking water from PVC pipes which have not been treated to remove the monomer, and in the wrappers and packaging of products.

Toxicity and Exposure: The major route of exposure is through inhalation for nearby residents and workers in manufacturing facilities, but exposure is also possible via ingestion of contaminated foods (packaged in PVC products), drinking water, and dermal contact through absorption of cosmetics (55). Those breathing high levels for short periods of time can experience dizziness, sleepiness or unconsciousness. Chronic exposure can result in permanent liver damage, immune reactions, nerve damage, and liver cancer. Upon release to soil, vinyl chloride rapidly volatilizes, but that which does not can become highly mobile in soil and eventually leach into the groundwater (52). Vinyl chloride does not bioconcentrate in aquatic life, it does not absorb in sediments, nor does it hydrolyze in water under normal aerobic conditions.

Vinyl chloride is found to be a carcinogen to people exposed to levels higher than MCLs (3). It can also cause acute effects which include central nervous system damage, numbness and loss of feeling in extremities, and discoloration of exposed skin. Long term exposure effects include damage to the liver and nervous system. Genotoxic effects include binding to DNA causing an adduct, (most commonly on the N7 position of guanine), and it can also depurinate the site making the DNA strand unreadable (9).

Mercury:

Physical and Chemical Properties: Mercury (Hg) is a naturally occurring metal that is liquid at room temperature with a molecular weight of 200.59 g/mol.. The element exists in three oxidation states: Hg^0 exists in the metallic form or as a vapor, Hg^+ is the mercurous state in which the mercury atom has lost one electron, and Hg^{2+} is the mercuric state in which the atom has lost two electrons (9). It has many applications in industry due to its fluidity, its uniform volume expansion over a wide temperature range, high surface tension and ability to alloy with other metals (4). It is mined from natural

ore deposits, and can combine with some elements to form inorganic mercury compounds or salts, or with carbon to form organic mercury compounds.

Common Uses: The largest use in the U.S. is for electrolytic production of chlorine and caustic soda in mercury battery cells (35% of use). Other uses include manufacture of wiring devices and switches (19%), measuring and control equipment (9%), dental equipment and filings (7%), electrical lighting (7%), and other uses (21%) (4). Mercury compounds are also used in aqueous preparations such as inks, adhesives, and caulking compounds. Many applications, such as use for bactericides and fungicides, have been banned in response to its high toxicity and push to limit exposure. When the McDermitt mine in Nevada closed in 1990, mercury ceased to be the principal product in the U.S. economy (4).

Amounts Produced/Released: As of 1998 there were 34 facilities that produce or process mercury in the U.S. Four of these are located in Louisiana: Borden Chemicals & Plastics in Geismer, DOW Chemical Co. in Plaquemine, Pioneer Chlor Alkali Co. Inc. in St. Gabriel, and PPG Industries Inc. in Lake Charles (4).

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of mercury in the state of Louisiana were 3,756 pounds for both on and off-site releases, 1,432 pounds to the atmosphere, 21 pounds to surface water, 1,577 pounds to land, and 0 pounds to underground injection (47). Mercury is mainly found in the atmosphere via degassing of vapors from the earth's crust. Once the mercury vapor is in the atmosphere it can be transported across the globe and then deposited to the earth through precipitation. The Environmental Defense Fund Scorecard

2001 statistics rank Louisiana as fifth in total reported environmental releases for mercury among the other states and territories (41).

Toxicity and Exposure: The most important organic compound to human toxicity is methyl mercury (CH_3Hg^+) (4). Methylated forms of mercury are available to enter into aquatic food chains and bioaccumulate in the organisms, eventually making their way to humans who consume the marine life. Sources of human exposure come through various occupational sources, inhalation, ingestion through the consumption of contaminated food, across placental barriers to a fetus, and also through dental fillings (53). Workers in the textile and clothing industry who were exposed to mercuric nitrates, used in the production of felt, were often called "MadHatters" due to the neurological effects the chemicals had on the body including delirium, hallucinations, or broad range functional problems such as loss of function or tremors.

Ingested elemental mercury is only slowly absorbed by the gastrointestinal tract, and generally thought to be of no toxicological impact. In relation, in a study of mercury found in food noted by Casarett & Doull (2001), around 15% of elemental mercury was absorbed by the gut, whereas 90 to 95% of methyl mercury was absorbed (9). Casarett & Doull (2001) also note that much higher concentrations of methyl mercury are found in blood than the elemental mercury (9).

After inhalation exposure, mercury vapors, which are lipid-soluble, are quickly absorbed into the lungs and then passed to the bloodstream and diffuse to all tissues in the body (9). When exposed, people can experience symptoms of generalized morning stiffness, skin rashes, joint pain, immune dysfunction, axillary lymph node swelling,

subcutaneous nodules, neurological symptoms such as ringing in the ears and/or burning and numbness sensations, or chronic fatigue (9). Mercury and its inorganic salts are found to have the highest concentrations in the kidneys after exposure, while methyl mercury tends to concentrate in the brain and central nervous system.

Its ability to cross placental barriers makes mercury especially dangerous to pregnant women. Casarett & Doull (2001) note that mercury found in fetuses, after the mothers exposure to alkyl-mercury, was two times higher than maternal tissues, and 30% higher in fetal red blood cells (9). Short or long term exposure can cause kidney damage in adults, but mercury is the most dangerous to children and pregnant women because of its propensity to cross the blood brain barrier and the placental barriers.

NERVE AGENTS/PESTICIDES

Nerve agents and pesticides are some of the most feared chemicals in the world. Their widespread use in military operations in WWI, WWII, the Iran-Iraq War (1983-85), and terrorist attacks such as the 1995 sarin attack on the Tokoyo subway system have affected many thousands of individuals. They were produced by the Germans from organophosphate insecticides and they cause over-stimulation of the central nervous system causing convulsions, loss of body control and/or death (53). While nerve agents were not available for this study, herbicides and pesticides, economically and industrially important to Louisiana were.

Herbicides

Atrazine:

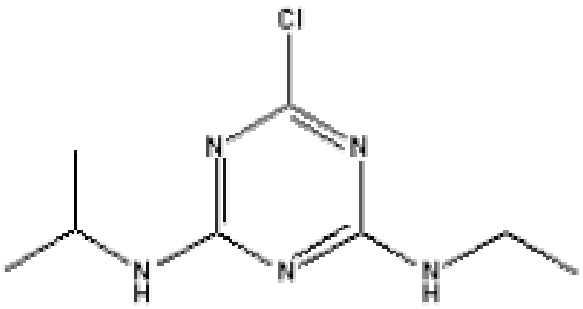


Figure 6. Schematic of Atrazine (Adapted from www.chemfinder.com)

Physical and Chemical Properties: Atrazine ($C_8H_{14}ClN_5$) is a white, colorless, nonflammable organic compound with a molecular weight of 215.69 g/mol. It maintains a high to medium mobility in soils and is more readily adsorbed on muck or clay soils than on soils of low clay & organic content (6). It may also strongly absorb to colloidal materials in the water column. Based upon a water solubility of 30 mg/L at 20ºC and a vapor pressure of 2.78 X 10^{-7} mm Hg at 20ºC, this indicates volatilization of atrazine from water will not be environmentally important (13). Trade names include Aatrex®, Atranex, Atred, and Vectal.

Common Uses: Atrazine is used as an herbicide for broadleaf and grassy weeds. It is a broad-spectrum triazine herbicide with pre- and post emergence activity from application (49). It can be found in several forms including suspension concentrates, wettable powders, liquids, and granules (6). It was estimated to be the most vastly used herbicide in the United States in 1987, and used extensively in Illinois, Indiana, Iowa, Kansas, Missouri, Nebraska, Ohio, Texas, Wisconsin, and Louisiana for weed control in corn and soybean fields (49). An estimated 65% of the corn crop in the U.S. is treated with atrazine (6). Since it is classified as a restricted use pesticide, it is not available to the

general public and only six companies in the U.S. are registered to produce atrazine or products containing it.

Amounts Produced/Released: Twenty-four facilities currently manufacture atrazine in the U.S., but Louisiana supports a lone facility that processes the largest amount: up to 49,999,999 pounds annually (6). 1974 saw the first onset of regulation of this substance through the passing of the Safe Drinking Water Act. Starting in 1998, the LDEQ and LDAF have been monitoring the upper Terrebonne Basin for atrazine after levels were found in excess of the MCL. The region has widespread use of atrazine in the sugarcane and corn fields in the area (the region's major crops).

According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of atrazine in the state of Louisiana were 33,647 pounds for both on and off-site releases, 18,816 pounds to the atmosphere, 668 pounds to surface waters, 0 pounds to land, and 535 pounds to underground injection (47). The Environmental Defense Fund Scorecard 2001 statistics rank Louisiana second in total reported environmental releases for atrazine among the other states and territories (41). The lone facility in Louisiana responsible for the total environmental releases reported is Syngenta Crop Protection Inc. located in Saint Gabriel. Atrazine levels in New Orleans tap water peaked at the national standard in 1999, but the annual average for that year was below the national standard. Levels were lower in 2000 and 2001(41).

Toxicity and Exposure: The Environmental Working Group reports that triazine pesticides are most frequently found in drinking water and they cause a variety of health effects (13). Atrazine has been shown to cause changes in blood hormone levels in animals that affected the ability to reproduce (6). Mammary gland cancer has been found

through repeated studies in female rats due to atrazine interfering with the normal functioning of the hormone system (13). Studies of couples living on farms that use atrazine for weed control found an increase in the risk of pre-term delivery (6). Acute health effects of atrazine at exposures above the MCL are attributed to symptoms of heart, lung and kidney congestion, hypotension, muscle spasms, weight loss, and/or adrenal degeneration (49). Chronic health effects from exposure above the MCL levels include cardiovascular damage, retinal and some muscle degeneration, and mammary tumors. There is a shortage of information in reference to the carcinogenicity of atrazine. Studies of human populations indicate that there may be a link between atrazine use and some types of cancer, but the information was not specific enough to make a definitive connection between atrazine and cancer.

The environmental fate of atrazine is evaluated through microbial degradation in soil, with photodegradation and volatilization being of little significance (13). The USFDA and USDA report that even though atrazine is used extensively on crops, few atrazine residues have been found in food analyses from 1987 to the present (13). In contrast, atrazine has been detected in many drinking water well samples in areas where it has been used on crops. Exposures are mainly coming from occupational exposures or through drinking water. The U.S. EPA reports that atrazine was found present in 1,750 CWS wells, and in 70,800 rural domestic wells (13).

Regulated Pesticide Mixture

A regulated pesticide mixture standard was provided for this study and it included 8 components which are all carbamate pesticides (See Table 1). Louisiana is ranked as first in total releases of carbofuran in relation to all other states. Therefore it is of

particular importance here and is more likely to be found contaminating drinking water sources.

Carbofuran:

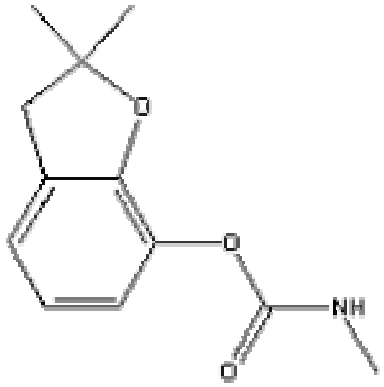


Figure 7. Schematic of Carbofuran (Adapted from www.chemfinder.com)

Physical and Chemical Properties: Carbofuran ($C_{12}H_{15}NO_3$) is a carbamate pesticide classified as a white crystalline solid with a phenolic odor, and a molecular weight of 221.3 g/mol (17). It is soluble in water at 700 mg/L. Trade names include Furadan, Curaterr and Carbamate.

Common Uses: Carbofuran is used as a pesticide on fruit, vegetables, tobacco, ornamentals and forest trees (52). It is applied at the ground as a granular or sprayed onto flora at an application rate of 0.5-10 lbs. a.i./acre. It is sprayed directly onto soil and plants just after emergence to control beetles, nematodes and rootworm (51). In the past, carbofuran was used primarily on corn crops. Currently it is allowed for use on only a few U.S. crops and soon to be banned on corn and sorghum in California. The greatest use is on alfalfa with rice, turf, and grapes making up most of the remainder (51).

Amounts Produced/Released: According to the U.S. EPA's Toxic Release Inventory 2001 data, the total environmental releases of carbofuran in the state of Louisiana were 505 pounds for both on and off-site releases, 500 pounds to the atmosphere, 5 pounds to

surface waters, 0 pounds to land, and 0 pounds to underground injection (47). The Environmental Defense Fund Scorecard 2001 statistics rank Louisiana first in total reported environmental releases for carbofuran among the other states and territories (41). FMC Corp. Agriculture Products Group in Opelousas is the facility responsible for the total environmental releases in the state of Louisiana (41).

The pesticide is a restricted product due to its "acute oral and inhalation toxicity to humans, and widespread bird kills when used in the granular forms" (13). It requires unique warning statements on labels for products containing carbofuran. Labeling on all products must bear statements reflecting the hazards to man and the environment: "This pesticide is toxic to fish, birds and other wildlife. Do not discharge into lakes, streams, ponds, estuaries, oceans, or public water unless this product is specifically identified and addressed in an NPDES permit" (17).

Toxicity and Exposure: Classified as a cholinesterase inhibitor, one will experience symptoms of weakness, headache, sweating, nausea, vomiting, diarrhea, tightness in the chest, blurred vision, pinpoint pupils, and abnormal flow of saliva upon contact with carbofuran (17). Atropine is used as an antidote for exposure. Carbofuran is metabolized rapidly in animals into less toxic and finally non-toxic metabolites. It is reported to have an acute oral toxicity – rats LD_{50} 3.8-34.5 mg/kg and mouse LD_{50} 14.4 mg/kg (17). The major routes of exposure are from inhalation in which workers apply it by ground or aerial spray to crops. Equipment to spray the pesticide increases the potential for exposure of humans, livestock and wildlife due to spray drift.

WATER TREATMENT FACILITY SITE SELECTION PARAMETERS

Before conducting the quality assurance testing, several parameters relevant to terrorism threats were evaluated. Parameters were used to determine which water treatment facilities would be tested:

1. What is the geography of the region the water treatment facility is in?
    a. What is the critical infrastructure of a region that would put it at risk for a terrorist threat?
2. What is the population size of the region?
    a. Does the region serve a population of sufficient size, over 100,000 people, to be a potential risk for a terrorist act?
3. What is the source of their raw water (surface or ground water)?
4. How is the water treated in that treatment plant (disinfection process in use or not)?
5. Are there geographical patterns in LA where cities or regions use ground vs. surface water?

Upon evaluating these parameters and corresponding with the staff in the SDWP, it became almost immediately evident that there would be limitations in choosing sites due to accessibility and security reasons. Therefore, under the direction of the SDWP, water was tested at a water treatment facility or well in each of the nine public health regions (See Figure 8) in the state of Louisiana.

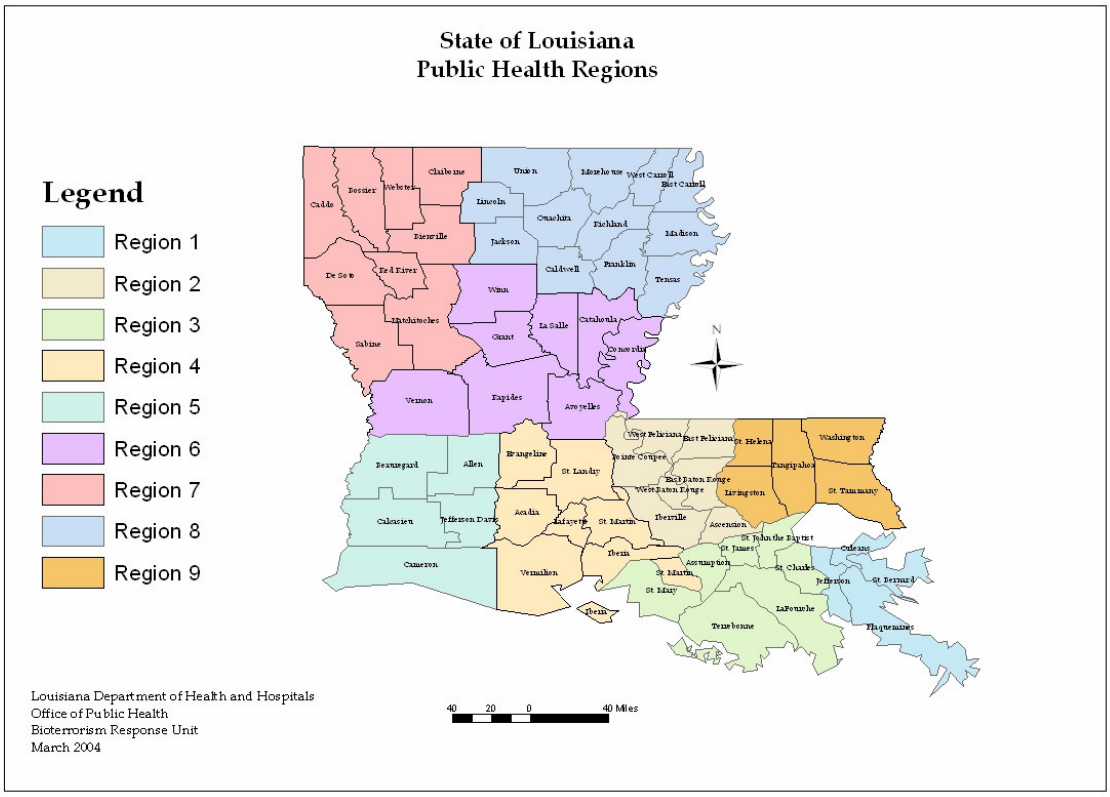


Figure 8. State of Louisiana Public Health Regions (Adapted from OPH – Bioterrorism Response Unit internal document)

Regional and Site Selection Data

Water treatment facilities were selected based on the criteria described earlier in addition to their need for a routine sanitary survey conducted during March, April, or May 2004. Due to this limitation of time, it was not feasible to always select a water treatment facility in a city serving a majority of the population in that region. Some facilities serving large populations may have already conducted a water survey for the year, and would not collect again until an undisclosed date in 2005. Due to stated factors, water treatment facilities serving small amounts of people are equally at risk for contamination and terrorism.

Region 1:

Parishes: Public Health Region 1 is a region which contains four Louisiana Parishes: Jefferson, Orleans, Plaquemines, and St. Bernard.

Population: The major city in this region is New Orleans. New Orleans is home to 1,337,726 people in the Metropolitan Statistical Area (MSA) and 484, 674 in the city limits (according to U.S. Census 2000 data) (29). See Table 4 for U.S. Census data for Region 1.

Table 4. U.S. Census data for Louisiana Public Health Region 1

Parish	2001 estimate population	2000 Population
Jefferson	451,459	455,466
Orleans	476,492	484,674
Plaquemines	27,004	26,757
St. Bernard	66,486	67,229
Totals:	**1,021,441**	**1,034,126**

Geography: New Orleans encompasses roughly 4,190 square miles, much of which is considered to be sitting in an up to -8 ft. below sea level "bowl". The majority of the city sits on the east bank of the Mississippi River, but the River also surrounds it to the west and south. Lake Pontchartrain, another major water system lies right north of New Orleans. Region 1 primarily takes its drinking water from surface waters including the Mississippi River, yet there are two aquifers that feed the region. These include the Chicot equivalent system and the Evangeline equivalent system.

Critical infrastructure: New Orleans is a huge tourist destination which sees around 7 million visitors annually. It is known for the famous French Quarter and Mardi Gras, an annual event which precedes the Christian season of Lent, which brings in around two million people to the city. New Orleans is also home to three public and five private universities, two community colleges, two medical schools, two law schools, and two

theological seminaries. It has one of the world's greatest international ports, one of the largest in the nation, and it is a major focus of the city's economy. New Orleans is home to the corporate offices of oil companies with major offshore operations in the Gulf of Mexico, as well as the distribution and service centers of offshore equipment suppliers and fabricators. The manufacturing industry is a significant part of the economy, with petroleum, petrochemical, shipbuilding, and aerospace industries all playing a role. The New Orleans region also functions as a mining, processing, and transportation center for other minerals, principally sulfur. Also, service industries are playing a larger role, with health care and telecommunications leading the way. The New Orleans region is widely regarded as a leading center of medicine and health care in the South.

Region 2:

Parishes: Public Health Region 2 is a region which contains seven Louisiana Parishes: Ascension, East Baton Rouge, East Feliciana, Iberville, Point Coupee, West Baton Rouge, and West Feliciana.

Population: Baton Rouge, the state capitol, is found in East Baton Rouge Parish and has an estimated population of around 602,894 people in the MSA, and 227,818 people in the city limits (29). See Table 5 for U.S. Census data for Region 2.

Table 5. U.S. Census data for Louisiana Public Health Region 2

Parish	2001 estimate population	2000 Population
Ascension	79,873	76,627
East Baton Rouge	409,667	412,852
East Feliciana	21,420	21,360
Iberville	33,261	33,320
Point Coupee	22,619	22,763
West Baton Rouge	21,726	21,601
West Feliciana	15,140	15,111
Totals:	**603,706**	**603,634**

Geography: Baton Rouge sits on the eastern bank of the Mississippi River. It has an average elevation of about 19 ft. above sea level, and it has about 75 square miles of land area. It is also located approximately 80 miles northwest of New Orleans. Region 2 is an area that takes its drinking water from ground water sources. Baton Rouge, the capitol also uses ground water despite the fact that the Mississippi River runs along the western boundary of the city. There are several aquifers that feed the region for its drinking water. They include the Chicot equivalent system, the Evangeline equivalent, and the Jasper equivalent, in addition to two statewide systems, the Mississippi River Alluvial, and the Upland Trace.

Critical infrastructure: Region 2 is home to the state flagship university, Louisiana State University, in Baton Rouge, as well as two other public universities, and a community college. Baton Rouge is a busy deepwater port of entry; an important transportation, distribution, and commercial center for a large oil, natural gas, and farm area; and a major oil-refining hub. The petrochemical and fuel corporation ExxonMobil has large facilities here and is one of Baton Rouge's major employers. Manufactures include concrete products, pharmaceuticals, food and beverages, chemicals, plastics, and resins.

Region 3:

Parishes: Public Health Region 3 is a region which contains seven Louisiana Parishes: Assumption, Lafourche, St. Charles, St. James, St. John the Baptist, St. Mary, and Terrebonne.

Population: Houma, located in Terrebonne Parish, is the largest city found in this region, and it has an estimated population of around 194,477 people in the MSA, and 32,393 people in the city limits (29). See Table 6 for U.S. Census data for Region 3.

Table 6. U.S. Census data for Louisiana Public Health Region 3

Parish	2001 estimate population	2000 Population
Assumption	23,257	23,388
Lafourche	90,273	89,974
St. Charles	48,548	48,072
St. James	21,224	21,216
St. John the Baptist	43,798	43,044
St. Mary	52,833	53,500
Terrebonne	105,123	104,503
Totals:	**385,056**	**383,697**

Geography: The elevation of the region ranges from sea level to approximately 20 ft above sea level. Region 3 comprises the southern central portion of Louisiana and is made up of wetlands, bayous, and marshes. In the southernmost parishes, more than 90 percent of the land is wetlands or covered by open water (permanently or seasonally). St. Charles Parish sits on a piece of land that is north of New Orleans on the Mississippi River. The entire Terrebonne Basin covers an area extending approximately 120 miles from the Mississippi River on the north to the Gulf of Mexico to the south, and the upper part is the sole drinking water source for over 250,000 people. There is one aquifer that is found in the region that ground water could be taken from, the Chicot equivalent system. There is not adequate water supply for the region from this aquifer therefore water from the Mississippi River is used for St. Charles Parish.

Critical infrastructure: Region 3 is home to one state University, Nicholls State located in Thibodaux. The major industry of this region is based on the petrochemical industry, sugar cane farming, and other agricultural products such as rice and soybeans. St. Mary and Terrebonne Parishes rely on the commercial fishing industry for additional revenues, as they are located on the shrimp, oyster, and fish filled Gulf of Mexico. Terrebonne Parish, the second largest parish in Louisiana in land area, now ranks first in the State

in natural gas production, third in oil, accounts for 25% of the State's seafood production, and its shipbuilding industry has benefited from the new demand for gambling boats.

Region 4:

Parishes: Public Health Region 4 is a region which contains seven Louisiana Parishes: Acadia, Evangeline, Iberia, Lafayette, St. Landry, St. Martin, and Vermilion.

Population: Lafayette, located in Lafayette Parish, is the largest city found in this region, and it has an estimated population of around 385,647 people in the MSA, and 110,257 people in the city limits (29). See Table 7 for U.S. Census data for Region 4.

Table 7. U.S. Census data for Louisiana Public Health Region 4

Parish	2001 estimate population	2000 Population
Acadia	58,910	58,861
Evangeline	35,546	35,434
Iberia	73,530	73,266
Lafayette	190,894	190,503
St. Landry	88,186	87,700
St. Martin	49,181	48,583
Vermilion	53,661	53,807
Totals:	**549,908**	**548,154**

Geography: Most of Lafayette Parish's 259 square miles and the surrounding parishes are composed of prairies, some alluvial plains, and forests interlaced with swamps, marshes, and bayous. Despite the large amount of waterways that run through the Region (Atchafalya River Basin, Bayou Teche, Lake Pelba, and Lake Bigeaux), Region 4 is an area that takes its drinking water from ground water sources. Even the city of Lafayette which is located on the Vermilion River uses groundwater sources for public drinking water. There are two aquifer systems that feed the region and they include the Chicot equivalent system and the Evangeline equivalent system.

Critical infrastructure: Lafayette Parish is the third smallest in the state yet it is a center for the state's oil and gas industry. Vermilion Parish is seated on the Gulf of Mexico and

around Vermilion Bay. The Intracoastal Waterway runs through the Parish. Two university systems are found in this region: Louisiana State University at Eunice, and University of Louisiana at Lafayette.

Region 5:

Parishes: Public Health Region 5 is a region which contains 5 Louisiana Parishes: Allen, Beauregard, Calcasieu, Cameron, and Jefferson Davis.

Population: Lake Charles, located in Calcasieu Parish, is the largest city found in this region, and it has an estimated population of around 183,577 people in the MSA, and 71,757 in the city limits (29). See Table 8 for U.S. Census data for Region 5.

Table 8. U.S. Census data for Louisiana Public Health Region 5

Parish	2001 estimate population	2000 Population
Allen	25,342	25,440
Beauregard	33,192	32,986
Calcasieu	182,842	183,577
Cameron	9,805	9,901
Jefferson Davis	31,275	31,435
Reg. 5 Totals:	**282,456**	**283,339**

Geography: The city of Lake Charles sits on Lake Charles at the mouth of the Calcasieu River. It is an important deepwater port and port of entry with a 30-mi-long channel connecting it with the Gulf of Mexico and the Intracoastal Waterway. Another water feature in the region is the Sabine River which borders Beauregard, Calcasieu, and Cameron Parishes to the West and creates the boundary between Louisiana and Texas. The regional terrain varies from marsh and wetlands to land with many bayous and lakes. The elevation of the land ranges from approximately 20 ft above sea level in the lower parishes up to 203 ft above sea level the farther inland one goes. The majority of Region 5 takes its drinking water from ground water sources, although there are small systems

that utilize surface waters. There are two aquifers that feed the region and they include the Chicot system and the Evangeline system.

Critical infrastructure: The region is in a rice, timber, oil, and natural gas region. The city of Lake Charles is an important producer of petrochemicals and has a variety of manufacturers, including machinery, concrete, transportation and oil-field equipment, food products. The proximity to the port of Lake Charles enables barges, and tugboats to navigate the waters and bring petroleum products, chemicals, rice, and cotton to the region. The region also is abundant in petroleum refineries and riverboat casinos, as well as in the seafood industry for fishing, crawfish, shrimp, and crabs. The region is home to one state university, McNeese State University.

Region 6:

Parishes: Public Health Region 6 is a region which contains 8 Louisiana Parishes: Avoylles, Catahoula, Concordia, Grant, LaSalle, Rapides, Vernon, and Winn.

Population: Alexandria, located in Rapides Parish, is the largest city found in this region, and it has an estimated population of around 126,337 people in the MSA, and 46,342 people in the city limits (29). See Table 9 for U.S. Census data for Region 6.

Table 9. U.S. Census data for Louisiana Public Health Region 6

Parish	2001 estimate population	2000 Population
Avoylles	41,458	41,481
Catahoula	10,847	10,920
Concordia	20,090	20,247
Grant	18,717	18,698
LaSalle	14,245	14,282
Rapides	126,566	126,337

(Table 9 continued)

Vernon	51,273	52,531
Winn	16,636	16,894
Reg. 6 Totals:	**299,832**	**301,390**

Geography: Alexandria, which sits in almost the geographic center of the state, lies on the south bank of the Red River. The terrain of the region is comprised of level plains, hills, long-leaf pine forests, yet interspersed with bayous and the rich Red River delta which makes for rich farmland. The elevation of the land ranges from 82 - 200 ft. above sea level. Louisiana's largest parish, Vernon Parish is in this region. Region 6 is an area that takes its drinking water from ground water sources. There are several aquifers that feed the region and they include the Cockfield system, the Evangeline system, the Jasper system, the Catahoula system, and statewide systems include the Red River Alluvial and the Upland Trace.

Critical infrastructure: The region is a medical headquarters for north and central Louisiana, and the industry employs a large majority of the people from the various parishes. Fort Polk, a major army base in Vernon Parish, brings military personnel to the area for training and preparedness activities. The major agricultural products of the region include rice, cattle, cotton, sugarcane, soy beans, alfalfa, and lumber. Extraction services for oil and gas production, lumber, and retail services are the major industries. The region is home to two universities Louisiana State University – Alexandria, and Louisiana College, in Pineville.

Region 7:

Parishes: Public Health Region 7 is a region which contains nine Louisiana Parishes: Bienville, Bossier, Caddo, Claiborne, DeSoto, Natchitoches, Red River, Sabine, and Webster.

Population: Shreveport, located in Caddo Parish, is the largest city found in this region, and is the third largest metropolitan city in Louisiana. It has an estimated population of around 392,302 people in the Shreveport-Bossier MSA, and 200,145 people in the city limits (29). See Table 10. for U.S. Census data for Region 7.

Table 10. U.S. Census data for Louisiana Public Health Region 7

Parish	2001 estimate population	2000 Population
Bienville	15,563	15,752
Bossier	99,285	98,310
Caddo	250,760	252,161
Claiborne	16,629	16,851
DeSoto	25,742	25,494
Natchitoches	38,558	39,080
Red River	9,578	9,622
Sabine	23,460	23,459
Webster	41,456	41,831
Reg. 7 Totals:	**521,031**	**522,560**

Geography: Bienvielle Parish is the home of the highest point in the state, The Driskill Mountain, at 535 ft above sea level. The elevations in this region range from approximately 150 - 535 ft above sea level. This region houses waterways including Cross Lake in Caddo Parish, the Toledo Bend Lake, the Red River and also the start of the Sabine River which acts as a boundary between Texas and Louisiana. Both Shreveport and Bossier City lie across the Red River which runs throughout the region. Region 7 is an area that takes its drinking water from surface water sources. There are

several aquifers though that feed the region and they include the Cockfield system, the Sparta system, the Catahoula system, the Jasper system, the Carrizo-Wilcox system, and statewide systems include the Red River Alluvial, and the Upland Trace.

Critical infrastructure: Shreveport is the commercial and cultural center of the Ark-La-Tex, the area where Arkansas, Louisiana and Texas meet. It is second in tourism to New Orleans, and has become a regional oil and natural gas center, with important metal, cotton, and lumber manufacturers. The region boasts dairy goods, feed and grain, machinery, household goods, and chemicals as the major industries. The region is the seat of Centenary College of Louisiana, Louisiana State University in Shreveport, the Louisiana State University School of Medicine in Shreveport, and the state fairgrounds. Barksdale Air Force Base, headquarters of the 2d U.S. Air Force, is located here. Nearby is Cross Lake located in Caddo Parish, with recreational facilities for tourists and locals.

Region 8:

Parishes: Public Health Region 8 is a region which contains 12 Louisiana Parishes: Caldwell, East Carroll, Franklin, Jackson, Lincoln, Madison, Morehouse, Ouachita, Richland, Tensas, Union, and West Carroll.

Population: Monroe, located in Ouachita Parish, is the largest city found in this region, and it has an estimated population of around 147,250 people in the MSA, and 53,107 people in the city limits (29). See Table 11. for U.S. Census data for Region 8.

Table 11. U.S. Census data for Louisiana Public Health Region 8

Parish	2001 estimate population	2000 Population
Caldwell	10,549	10,560
East Carroll	9,224	9,421
Franklin	21,018	21,263
Jackson	15,409	15,397

(Table 11 continued)

Lincoln	42,173	42,509
Madison	13,506	13,728
Morehouse	30,675	31,021
Ouachita	146,678	147,250
Richland	20,930	20,981
Tensas	6,507	6,618
Union	22,869	22,803
West Carroll	12,160	12,314
Reg. 8 Totals:	**351,698**	**353,865**

Geography: Region 8 is found in the northeast portion of Louisiana, bordered on the north by Arkansas, and to the east by Mississippi. Swamps, bottomland hardwood forests and pine-forested hills make up the natural countryside surrounding Monroe. The city of Monroe is broken up into West Monroe and Monroe as each are located on opposite banks of the Ouachita River. The Boeuf River also runs through this region and both rivers lie within miles of forestland, agricultural and cropland and pastures. The elevation in this region is among the highest in the state, being over three hundred feet above mean sea level near Ruston, though creek and stream bottoms are often closer to one hundred feet. This is not surprising in this land of hills and valleys. Region 8 is an area that takes its drinking water from surface water sources despite the several aquifers that feed the region: the Cockfield system, the Sparta system, and statewide systems including the Mississippi River Alluvial, and the Upland Trace.

Critical infrastructure: Monroe is the urban center of northeast Louisiana. It is home to CenturyTel, which is the only Monroe-based company listed on the New York Stock Exchange. It is also the birthplace of Delta Air Lines and home to the first Coca-Cola bottling plant. The other major industries that have settled here include the State Farm Insurance Regional Office, the General Motors Delphi Plant, and a regional office of the

Chase-Manhattan Mortgage Company. Chemical industry is abundant in this region with methanol and ammonia producers such as Koch Nitrogen being prominent, as well as automobile parts production. This region, like Region 6, acts as a medical hub for a 16-parish radius with eight hospitals and specialty centers in the area. Region 8 is also home to four state universities including the University of Louisiana at Monroe, Northeast Louisiana University, Louisiana Tech University, and Grambling State University.

Region 9:

Parishes: Public Health Region 9 is a region which contains 5 Louisiana Parishes: Livingston, St. Helena, St. Tammany, Tangipahoa, and Washington.

Population: Slidell, located in St. Tammany Parish, is the largest city found in this region, and it has an estimated population of around 25,695 people (9). See Table 12 for U.S. Census data for Region 9.

Table 12. U.S. Census data for Louisiana Public Health Region 9

Parish	2001 estimate population	2000 Population
Livingston	96,257	91,814
St. Helena	10,360	10,525
St. Tammany	197,683	191,268
Tangipahoa	101,930	100,588
Washington	44,072	43,926
Totals:	**450,302**	**438,121**

Geography: Region 9 consists of 3,735 square miles of area: 3,370 square miles of land area and 365 square miles of water area. Region 9 is an area that takes its drinking water from ground water sources. Covington is 9 ft above sea level, located 40 miles from New Orleans and is the county seat for St. Tammany Parish. It has about 6.9 square miles of land area and is home to roughly 8,483 people according to 2000 US Census data (29). There are several aquifers that feed the region and they include the Chicot equivalent

system, the Evangeline equivalent system, the Jasper equivalent system, and statewide systems include the Upland Trace.

Critical infrastructure: Located near New Orleans, and over Lake Pontchartrain, Slidell became a gateway out of the New Orleans area with help from the railroad and the highways. Many of the areas of Region 9 have experienced tremendous growth in recent years as suburban sprawl has taken a hold outside the major cities of Louisiana. St. Tammany has made an excellent place to live for those who want to escape big city life from New Orleans. The region contains one four-year university, Southeastern Louisiana University in Tangipahoa Parish. The region became known for its natural springs, the most famous being in the town of Abita Springs. The region exports thousands of gallons of water daily. The region's major industries include shipbuilding, the forestry industry, commercial fishing, nurseries, farming, and livestock.

MATERIALS AND METHODS

SAMPLING SITES

Region 1

Site Selection: Water was collected on 04/07/2004 from the Oak Street Surface Water Intake facility in New Orleans, LA. This facility is part of the New Orleans Carrolton Water Way system located in Jefferson Parish, New Orleans, LA. Tap water was collected for analysis from a tap in the facility laboratory located on Claiborne Ave in Orleans Parish. The Oak Street Facility takes in surface water from the Mississippi River. The facility serves an estimated 440,230 people and 13 different entities including industrial surface water intakes and surface water treatment plants. Water treatment at this location is performed by disinfection with hypochlorination, coagulation for removal of inorganics, rapid sand filtration for removal of organics, and pH adjustment for corrosion control. Detailed site location map of intake facility and the New Orelans Carrolton Water Way system found in Appendix M.

Region 2

Site Selection: Water was collected on 03/16/2004 from the drilled well at the Scenic Highway Treatment Plant, in Baton Rouge, LA, which is part of the Parish Water Company. The Parish Water Company services water to an estimated 122,500 people and 97 different facilities (including subdivisions, treatment plants, and storage facilities) in the Baton Rouge area, and they take their water from the Southern Hills aquifer which is part of the Chicot Equivalent System. The treatment plant uses chlorination for disinfection of water at this site. Water samples collected were drawn from the tap at the

well discharge line. Detailed site location map of well site and Parish Water Company found in Appendix N.

Region 3

Site Selection: Water was collected on 04/06/2004 from the Surface Water Intake Facility in Norco, LA, which is part of the St. Charles Water Dist. No. 1 in St. Charles Parish. Tap water was collected for analysis from a tap in a facility laboratory located in Luling, LA. The city of Norco is home to roughly 3,579 people, whom are mainly retired former workers of the New Orleans Refinery Co, after which the town is named from the acronym. St. Charles Water Dist. No. 1 is a water treatment facility servicing 24,081 people and 3 entities including a surface water treatment plant. Norco takes in water from the Mississippi River and treats it by using a number of treatment functions. They are: coagulation-flocculation performed as a clarification method, filtration for removal of small particles is conducted through a sand/gravel media, disinfection via chlorine anhydrous ammonia is used to kill harmful bacteria, fluoridation is performed by adding hydrofluosilicic acid for prevention of dental cavities, a corrosion inhibitor sodium zinc phosphate is used to prevent rusting and metal leaching, and powdered activated carbon is added to remove organics and to improve the taste and color of the water. Detailed site location map of the Surface Water Treatment Plant and the St. Charles Water District #1 found in Appendix O.

Region 4

Site Selection: Water was collected on 05/03/2004 from Well #1 in Esther, LA, which is a part of the Water Works #1 System located in Vermilion Parish. Water Works #1 is a water system that has not been put online yet and has no disinfection treatment in place.

Currently it services a total calculated daily population of 25 people and four entities including two wells, a treatment plant and a distribution facility. Census data was not available for the city of Esther, but Abbeville, the Parish seat has an estimated 11,887 people. The water sample collected was taken during a synthetic organic routine water sample from the drilled well and drawn directly from the well. It is noted that the ATSDR produced a public health assessment on water from Vermilion Parish in 1992 stating that arsenic was detected at elevated levels (levels that exceed ATSDR's comparison values) in some of the monitoring wells and in some of the surrounding residential wells (5). They noted that the presence of arsenic in the groundwater is believed to be unrelated to site contamination but rather representative of natural background levels found in the area. They found arsenic levels to be near the EPA chronic oral RfD for both children and adults. Detailed site location map of well #1 and the Water Works #1 System found in Appendix P.

Region 5

Site Selection: Water was collected on 05/06/2004 from a tap at Well G#10 West Plant in Lake Charles, LA, a drilled well which is part of the City of Lake Charles Water Division. The City of Lake Charles Water Division is a water system in Calcasieu Parish drawing its water from the Chicot aquifer. It services an estimated 80,000 people and 35 entities (including 28 wells, distribution systems and ground water treatment facilities). Well G#10 uses post hypochlorination as its disinfection method. Detailed site location map of Well G#10 and the City of Lake Charles Water Division found in Appendix Q.

Region 6

Site Selection: Water was collected on 3/29/2004 from Well R-1330, a drilled chlorination well located in Alexandria, LA, which is part of the City of Alexandria Water Supply. The well is used to service Hwy 1 North, 1st Road North, and the Rapides Golf and Country Club. Specific information on the ground water aquifer source was not provided. The City of Alexandria Water Supply is a water treatment facility servicing an estimated 62,210 people and 88 different facilities (including chlorination wells, industrial parks, and several city wells) in the Alexandria area. Well R-1330 uses gaseous chlorination to disinfect the water at this site. The water sample collected was taken during a synthetic organic routine water sample from the drilled well and drawn from the tap at the well discharge line. Detailed site location map of Well R-1330 and the City of Alexandria Water Supply found in Appendix R.

Region 7

Site Selection: Water was collected on 3/30/2004 from a secured faucet tap outside the facility gates at the D'Amiss Treatment Plant in Shreveport, LA, a part of the Shreveport Water System, in conjunction with a routine cyanide analysis water sample. This water system draws drinking water from the Cross Lake Surface Water Intake, a surface water source, in Shreveport. The Shreveport Water System is a water treatment facility servicing an estimated 210,000 people and seven different entities (including pump stations and treatment plants) in Caddo Parish. The facility uses a post hypochlorination method to treat the water. Detailed site location map of the Cross Lake Surface Water Intake and the Shreveport Water System found in Appendix S.

Region 8

Site Selection: Water was collected on 05/11/2004 from Well #3, located in Quitman, LA in Jackson Parish, which is part of the Punkin Center Hilltop Water System. Region 8 typically uses surface water sources for drinking water, but the Punkin Center Water System draws its water from the Sparta aquifer, a ground water source. It services over 1,880 people and 12 entities (including 4 wells, a hydropneumatic plant and 4 treatment plants). This treatment site uses a post hypochlorination method to disinfect its water. Detailed site location map of Well #3 and the Punkin Center Hilltop Water System found in Appendix T.

Region 9

Site Selection: Water was collected on 3/15/2004 from the Arrowood Well, a drilled water well source, in Covington, LA, which is part of the North Park Water Supply. North Park Water Supply is a water treatment facility servicing an estimated 9,648 people and thirteen different entities (including subdivisions, wells, and businesses) in the Covington area. Arrowood is a subdivision in the city that provides water to its residents, a fraction of the 9,648 people in the service district. The facility did not report a disinfection method to treat the water from this ground water source. Water samples collected were from a tap at the water discharge line. Detailed site location map of the Arrowood Well site and North Park Water Supply found in Appendix U.

TEST DESIGN AND PROCEDURES

Sampling Methods

Water samples from each region were obtained from sampling sites during a three month period from March 2004 to May 2004, in accordance with routine sanitary surveys and sanitary codes. See Table 13 for summarized site selection data.

Table 13. Site Selection Data for Water Samples in Each Region Including Treatment Type

Region	City	Water System	Water Source	Population Size Served	Treatment Type	Date water collected
1	New Orleans	New Orleans Carrolton Water Way	Oak St. Surface Water Intake	440,230	Hypo-chlorination, Coagulation, Filtration & pH adjustment	4/07/04
2	Baton Rouge	Parish Water Company	Scenic Hwy. Treatment	122,500	Chlorination	3/16/04
3	Norco	St. Charles Water Dist. #1	St. Charles Water Dist. #1	24,081	Post hypo-chlorination	4/06/04
4	Esther	Water Works #1	Well #1	25	None	05/03/04
5	Lake Charles	City of LC Water Div.	Well G#10 West Plant	~80,000	Post hypo-chlorination	05/06/04
6	Alexandria	City of Alexandria	Well R-1330	62,210	Gaseous Chlorination	3/29/04
7	Shreveport	Shreveport Water System	Cross Lake Surface Water Intake	210,000	Post hypo-chlorination	3/30/04
8	Quitman	Punkin Center Hilltop WS	Well #3	1,880	Post hypo-chlorination	05/11/04
9	Covington	North Park Water Supply	Arrowood Well	9,648	None	3/15/04

Water collected for sanitary surveys was analyzed at the OPH central lab, in New Orleans, using gas chromatography for potential interferences and/or trace amounts of chemicals found as background levels in the water. (See Appendices D-L for Central Lab Reports on each region's water samples) Approximately 4 liters of tap water were collected at each site in either high-density polyethylene (HDPE) containers, or in 4 liter glass amber bottles provided by the OPH central labs (Figure 9). Samples were acquired

from either a tap at the well discharge line or from a tap in the facility laboratory. Samples were stored in cool ice chests until brought to the lab where they were kept at a refrigerated temperature of 7º C in their respective containers.

Figure 9. Water Collection Containers

Test Sample Preparation and Storage

Chemical standards tested during the experiments were supplied by OPH Central Labs. The metal standards (mercury, lead, arsenic and chromium) came from Spex CertiPrep, Inc. while all other standards (volatile liquid mixture, volatile gas mixture, regulated pesticide mixture and atrazine) came from AccuStandard. Their product data are listed below in Table 14. Chemical mixture components are listed in Table 1.

Table 14. Chemical Standards Provided by OPH Central Labs

Chemical	Concentration	Solution	Starting Volume	Chemical Components
Mercury	1,000 mg/L	10% HNO	Approx. 50 mL	Hg
Atrazine	1,000 mg/L	In methanol (MeOH)	1 mL	Atrazine
Volatile Liquid Mixture	2.0 mg/mL of each component*	In methanol (MeOH)	1 mL	54 volatile liquid components
Volatile Gas Mixture	2.0 mg/mL of each component	In methanol (MeOH)	1 mL	6 volatile gas components
Regulated Pesticide Mixture	0.1 mg/mL	In AcCN	1 mL	8 pesticide components

* exception: *cis*-1,3-Dichloropropene at 1.06mg/mL
trans-1,3-Dichlorpropene at 0.94 mg/mL

Chemical Dilutions

Serial dilutions were prepared on each chemical standard in order to perform tests at two or three different concentrations. Dilutions were prepared based on the ECLOX-M™ limit of detection for that chemical, and the concentration of the chemical at 100, 1,000, or 10,000 times their MCL level (see Table 15). Severn Trent does not give a limit of detection for Atrazine, nor any of the components of the volatile liquid or gas mixtures. Therefore, the dilutions for atrazine were based off of its MCL level, 0.003 mg/L; the dilutions for the volatile liquid mixture were based off of the MCL level for trichloroethylene, 0.005 mg/L; and the dilutions for the volatile gas mixture were based off of the MCL level for carbofuran, 0.04 mg/L (see Table 3).

Dilutions were prepared by mixing HPLC grade, de-ionized water with the correct proportion of each chemical to create the appropriate concentration. Dilutions for mercury were prepared 9 days prior to the start of the testing and refrigerated at 8°C in volumetric glassware for a maximum of 60 days. Atrazine dilutions were prepared 1 day prior to the start of testing and refrigerated at 8°C in dark amber glassware. All other chemical dilutions were prepared on the same day that they were tested, and remaining chemical was refrigerated at 8°C in dark amber glassware. Two mixed chemical samples were also prepared: 1) a metal mixture which contained mercury at 2 mg/L, lead at 15 mg/L, and atrazine at 3 mg/L, and 2) a volatile organic compound mixture which contained the volatile liquid mix at 5 mg/L, the volatile gas mix at 5 mg/L, and the regulated pesticide mix at 4 mg/L. The mixed chemical samples were prepared on the same day of testing and maintained at room temperature.

Testing

A method blank sample consisting of HPLC grade, de-ionized water was analyzed once by ECLOX-M™ for approximately every 10 samples that were analyzed. The method blank is the first sample run and is treated as the control sample that is used to correct the response of the instrument with respect to a clean water sample. Next, three replicates of each contaminant, at each concentration level were evaluated to assess the ability of ECLOX-M™ to detect toxicity at various concentrations of contaminants. They were also tested to measure the precision of ECLOX-M™ results. Percent inhibition for each analysis was recorded. Unspiked drinking water samples were also run in triplicate and inhibition results evaluated to measure ECLOX-M™ precision and to set the background inhibition of the sampled water. These results were then compared to OPH Central Lab Reports for comparison of ECLOX-M™ results to OPH GC analysis.

Lastly, regional drinking water samples fortified with contaminants (spiked samples) were evaluated to measure the effect that the contaminants would have on the drinking water samples. The number of samples analyzed depended on the amount of chemical standard dilution available for the test. Spiked water samples were prepared by mixing 1 mL of the water sample with a spike consisting of 1% of the chemical standard dilution concentration. A spike was prepared and analyzed for each of the dilution concentrations created to determine the effects the chemicals would have as a mixture with the water samples. See Table 1 for data on chemical standards that were provided by OPH central labs.

In order to test the validity of the ECLOX-M™ in producing repeatable results on the machines purchased, a simultaneous test was run on two machines: the SDWP and

the Region 2 machine. Chemical standards in two concentrations were run on both ECLOX-M™ machines simultaneously, and percent inhibition recorded.

The reagents needed for the chemiluminescence reaction were provided by Severn Trent Services to the OPH (See Figure 10). They are temperature sensitive and they will degrade at high temperatures. CT Reagent 1 has a refrigerated life of 2 years, diluted CT Reagent 2 has a refrigerated life of 1 year, and diluted CT Reagent 3 has a refrigerated life of 1 year. (See Appendix D for reagent stability information). Prior to testing, reagents were prepared according to the ECLOX-M™ operating manual and they were kept refrigerated at 4°C until used in the experiments. It is noted here that for the experiments there was a limited supply of reagents for analyzing all of the samples.

Table 15. Summary of Quality Control and Contaminant Test Samples

Type of Sample	Sample Characteristics	Concentration Levels (mg/L)	No. of Sample Analyses
Quality control	Positive Control – Method blank	NA(a)	6-9
	Unspiked Drinking Water	NA	3
Standards	Mercury	20 & 2	3 per concentration level
	Atrazine	30 & 3	3 per concentration level
	Volatile Liquid Mixture (54 components)	50 & 5	3 per concentration level
	Volatile Gas Mixture (6 components)	100, 50 & 5	2 at 100 mg/L 3 at 50 & 5 mg/L
	Regulated Pesticide Mixture (8 components)	40 & 4	3 per concentration level
Spiked Samples	Mercury	20 & 2[(b)]	2 or 3 per concentration level
	Atrazine	30 & 3[(c)]	1 per concentration level
	Volatile Liquid Mixture	50 & 5[(d)]	1 per concentration level
	Volatile Gas Mixture	100 & 5[(e)]	1 per concentration level
	Regulated Pesticide Mixture	40 & 4[(f)]	1 per concentration level

(Table 15 continued)

Simultaneous Testing of Standards on the SDWP & Region 2 ECLOX-M™	Mercury	20 & 2	1 per concentration level
	Atrazine	30 & 3	1 per concentration level
	Regulated Pesticide Mixture	40 & 4	1 per concentration level
	Volatile Liquid Mixture	50 & 5	1 per concentration level
	Volatile Gas Mixture	50 & 5	1 per concentration level
	Lead	150 & 15	1 per concentration level

[a] NA=Samples not fortified with any contaminant or potential interference
[b] Spike containing 20 µL of 1,000 mg/L Mercury and 2 µL of 1,000 mg/L Mercury respectively
[c] Spike containing 30 µL of 1,000 mg/L and 3 µL of 1,000 mg/L Atrazine respectively
[d] Spike containing 25 µL of 2,000 mg/L and 2.5 µL of 2,000 mg/L Volatile Liquid Mixture respectively
[e] Spike containing 50 µL of 2,000 mg/L and 5 µL of 10 mg/L Volatile Gas Mix respectively
[f] Spike containing 4 µL of 100 mg/L and 4 µL of 10 mg/L Regulated Pesticide Mixture respectively

WATER QUALITY ANALYSIS

Chemiluminescence

The ECLOX-M™ was used to measure the light inhibition of chemical standard dilutions, chemical mixtures, water samples, and spiked water samples. The cuvettes for the machine were 10 mL clear plastic cuvettes that used 1 mL of sample for each test run. The machine compared each contaminant and water sample to a blank sample containing HPLC grade, de-ionized water and the three reagents needed to produce light. The blank was used as a reference sample to determine the maximum light output in the absence of contaminants. It produces a baseline of light with a signal range from 300-900. If the baseline signal was below 300 it meant that the reagents were unusable. Each sample was analyzed and the percent light inhibition recorded (See Figure 11).

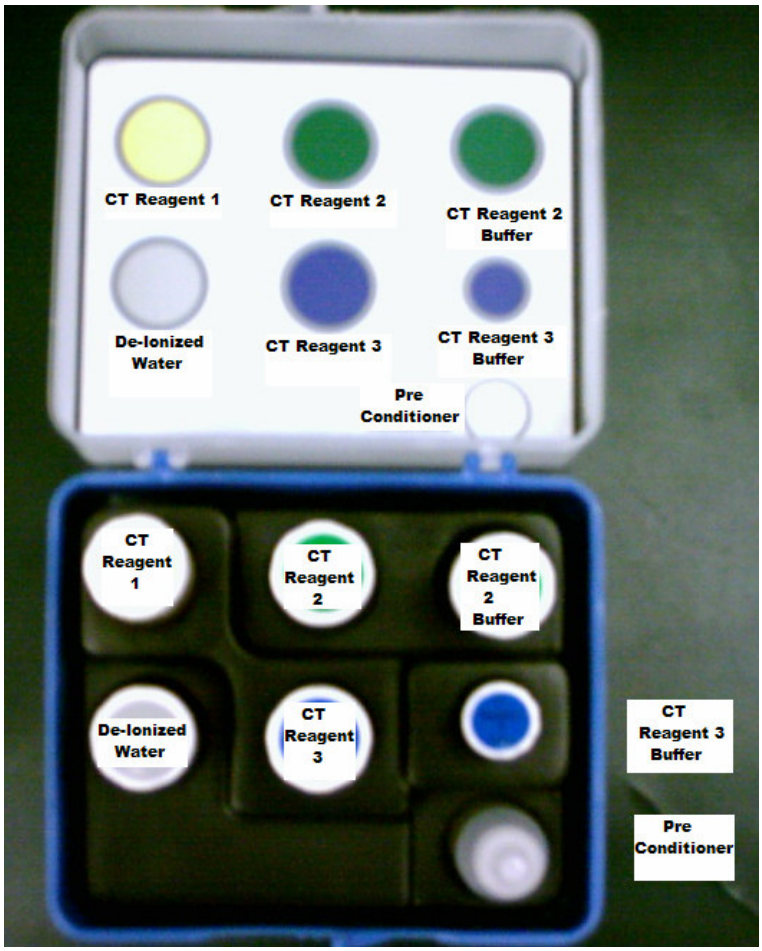


Figure 10. Chemiluminescence Reagents Provided by Severn Trent Services.

To analyze any sample (reference, water sample or chemical standard dilution), 100 µL of the three reagents were added to 1 mL of the sample to be analyzed. The sample cuvette was placed in the ECLOX-M™ immediately, and analyzed for four minutes. The ECLOX-M™ automatically calculated the percent inhibition for each sample. For spiked water samples, 1 mL of drinking water sample was mixed with the 1% chemical spike first, then 100 µL of each reagent was added and the sample cuvette was placed in the ECLOX-M™ for analysis.

Reference Sample and Measure Sample LCD Display

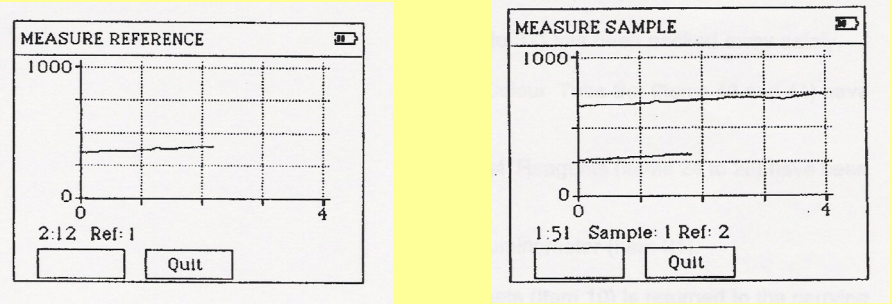


Figure 11. Reference Sample and Measure Sample LCD Display

Chlorine

Prior to analyzing drinking water samples on the ECLOX-M™, chlorine content was tested to rule out any possible interference of chlorine on the chemiluminescence test. Free chlorine can inhibit the chemiluminescent reaction that generates the light production within the ECLOX-M™ reagent. The chlorine test utilizes a piece of equipment called the Checkit (see Figure 12). The stopper on the top of the Checkit was removed and 10 mL of the water sample was added to the left-handed compartment. One DPD No. 1 Chlorine Tablet was removed from its foil packet and added to the water. The stirring rod provided was used to crush the tablet. The stopper lid was placed back on the Checkit and the unit was shaken, and then left to sit for one minute. Color produced was compared against a color chart on the unit which indicated amount of free chlorine concentration in mg/L. Due to a limited supply of Chlorine Tablets, not all regional water samples were tested. Other disinfecting chemicals such as bromine, iodine, and manganese react to this test, as does chlorine.

Chlorine Checkit

Figure 12. Chlorine Checkit

pH

The pH test was conducted on all water samples in concurrence with chemiluminescence testing of each chemical standard set. A pH meter is standard equipment with the ECLOX-M™ system (see Figure 13). Before use, the pH meter was calibrated to pH 6.9 with a standard solution. All samples were brought to room temperature (23°C) and were placed on a stir plate before being analyzed. The pH meter was held in the water sample for approximately 30 seconds to allow the measurement to settle out before recording results.

Pesticide Test Strips

Test strips were used to test reference samples, drinking water samples, as well as a 30 mg/L and 3 mg/L standard of Atrazine, and 40 mg/L and 4 mg/L standard of the Regulated Pesticide Mixture. Test strips contain a white disk at one end and a larger pink disk at the other end, with a protective film covering both (See Figure 14). For each test,

pH Meter

Figure 13. pH Meter

the protective film was folded back to expose the white disk and then it was submerged into beakers of reference and drinking water samples for one minute. For chemical standards, 200µL of the sample was pipetted onto the white disc and remained there for one minute. After one minute the protective film covering the pink disk was removed and the strip was folded in half exposing the white disk to the pink disk. The strip was then inserted into the pesticide clip and put back into the original foil packet. The packet was kept warm by placing under the armpit (outside clothes) for 4 minutes. After the test is complete, a blue disc indicates that no pesticide or nerve agent was present, and a white disc indicates that pesticide or nerve agent is present.

Pesticide Test Strips

Figure 14. Pesticide Test Strips

Arsenic Tests

The sensitivity of the arsenic test to chemicals other than arsenic was unknown, therefore various metals were tested in addition to arsenic to determine sensitivity. Reference water, drinking water samples, two mercury dilution standards at 20 mg/L and 2 mg/L, a lead dilution standard at 150 mg/L, a chromium dilution standard at 100 mg/L, and an arsenic chemical standard at 1,000 mg/L were tested. Arsenic test strips were stored in the AT Test Strips tin to protect the reaction zone (small square pad) at the end of each strip. Samples were tested first by removing one test strip from the tin. Holding the strip with the reaction zone downward, it is inserted into the slit of the cap on the AT Test Tube. The AT Test Tube was rinsed out with sample and then approximately 2 mL was poured into the tube. 1 spoonful of AT Reagent 1 was added and then swirled in to mix. Next 10 drops of AT Reagent 2 were added and the cap was immediately added to the tube. The tube was left to stand for 15-20 minutes and the contents swirled 3 times during this time. After the time was up, the strip was removed and the color on the reaction zone was compared to the color chart on the side of the AT Test Strips tin (see Figure 15).

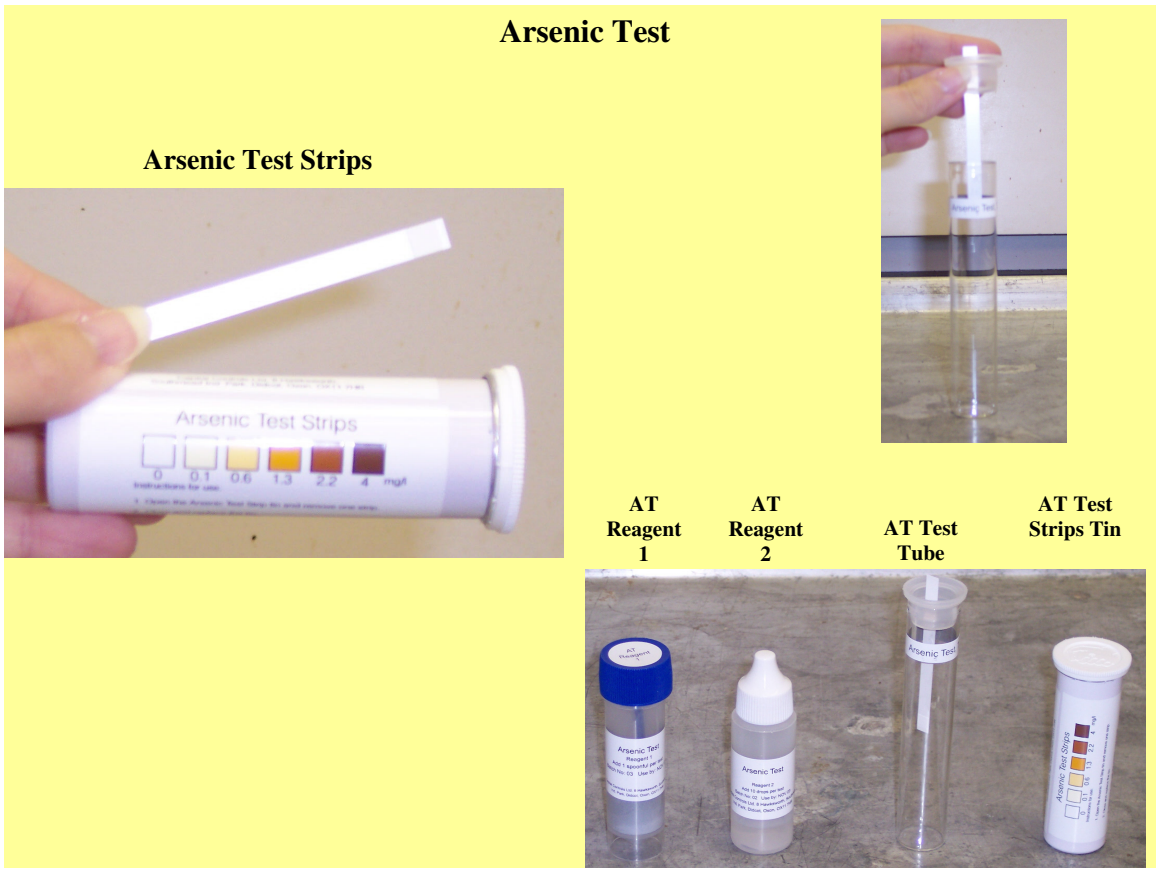


Figure 15. Arsenic Test

RESULTS AND ANALYSIS

Water samples from nine Louisiana OPH regions were obtained and tested for chemiluminescence and light inhibition, chlorine content, pH, arsenic and pesticide/nerve agent contamination using the ECLOX-M™ kit. Light inhibition results were recorded for chemical standards (mercury, atrazine, a regulated pesticide mixture, a volatile liquid mixture, and a volatile gas mixture) at two concentrations of each chemical. This was done to assess the ability of the ECLOX-M™ to detect toxicity at various concentrations of contaminants, as well as to measure the precision of ECLOX-M™ results. The experiments aimed to assist the OPH SDWP in determining the functionality, precision, and accuracy of the ECLOX-M™ as a surveillance system for detecting terrorism and contamination threats to Louisiana's public drinking water systems.

WATER SAMPLES

Three surface water sites were sampled and six ground water sites were sampled from the nine OPH regions (See Table 13). Unspiked water samples were analyzed in triplicate, by the ECLOX-M™ chemiluminescence test, prior to each chemical standard that was tested. A one-way analysis of variance revealed that there was a significant difference between the nine regional water samples and their percent inhibition results ($p \leq 0.01$). The subsequent Table and Figure illustrate the average percent inhibition for water samples from all nine regions. Samples that produced negative percent inhibition values indicated an increase in light production by the enzyme relative to the HPLC grade de-ionized water method blank.

Table 16. Average Percent Inhibition for Regional Water Samples

OPH Region	Water Source	Average Inhibition (%)	Standard Deviation (%)
1	Surface	-2	3
2	Ground	19	8
3	Surface	-2	10
4	Ground	80	2
5	Ground	87	2
6	Ground	12	5
7	Surface	12	27
8	Ground	25	10
9	Ground	37	7

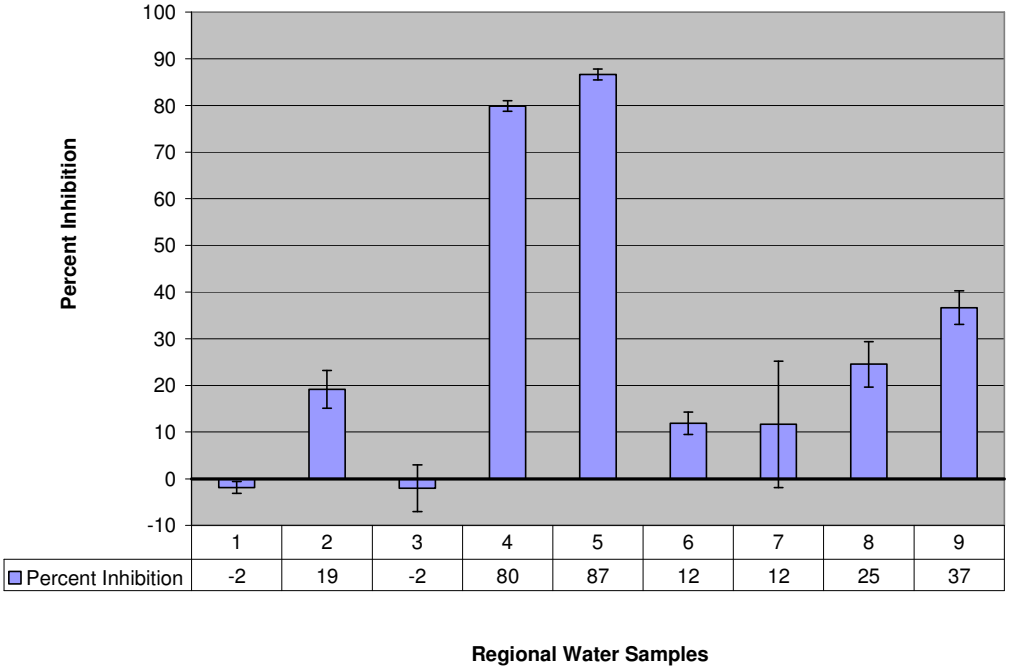


Figure 16. Average Percent Inhibition for Regional Water Samples

In addition to analysis from the ECLOX-M™, water samples were also analyzed by methods including gas chromatography from OPH Central Labs to report nitrates, cyanide, water quality parameters, metals, radiation particles, PAH's, and volatile organic compounds. OPH Central Labs did not always provide complete information on each water sample tested (See Appendices D-L for complete OPH Central Lab Reports). Contaminants reported in the Lab Reports for all nine water samples collected, are depicted in Tables 17 through 25. Standard qualifiers in the Lab Reports often are reported as out of control, therefore for those chemicals it is undetermined whether or not they are found in the water sample, or that results are accurate. OPH Central Labs did not report results on nitrates, cyanide, water quality parameters, metals or radiation particles for Regions 2 and 9. The only information available was for volatile organic compounds (see Appendices E & L).

Table 17. Contaminants Found in Region 1 Water as Reported by OPH Central Labs

Region 1		
Contaminants	**Concentration**	**Qualifiers out of Control**
Nitrate	2 mg/L	Bis (2-Ethylhexyl) Adipate
Flouride	1.0 mg/L	Benzo(a)pyrene
Sulfate	52 mg/L as SO4	Chloroform
Chloride	36.0 mg/L	Chlorobenzene
Iron	0.02 mg/L	o-Xylene
Sodium	19.6 mg/L	Styrene
Potassium	2.5 mg/L	Bromoform
Aluminum	0.11 mg/L	o-Dichlorobenzene
Gross alpha activity	2 pCi/L	1,2,4-Trichlorobenzene
Chloroform	25.4 µg/L	
Bromodichloromethane	10.1 µg/L	
Chlorodibromomethane	2.5 µg/L	

Table 18. Contaminants Found in Region 2 Water as Reported by OPH Central Labs

Region 2
Qualifiers out of Control
p-Dichlorobenzene
o-Dichlorobenzene
1,2,4-Trichlorobenzene

Table 19. Contaminants Found in Region 3 Water as Reported by OPH Central Labs

Region 3		
Contaminants	**Concentration**	**Qualifiers out of Control**
Nitrate	2 mg/L	Bis (2-Ethylhexyl) Adipate
Flouride	0.8 mg/L	Benzo(a)pyrene
Sulfate	44 mg/L as SO4	Chloroform
Chloride	34.2 mg/L	Chlorobenzene
Iron	0.03 mg/L	o-Xylene
Sodium	19.4 mg/L	Styrene
Potassium	2.7 mg/L	Bromoform
Aluminum	0.06 mg/L	o-Dichlorobenzene
Chloroform	31.0 µg/L	1,2,4-Trichlorobenzene
Bromodichloromethane	16.4 µg/L	
Chlorodibromomethane	4.4 µg/L	

Table 20. Contaminants Found in Region 4 Water as Reported by OPH Central Labs

Region 4		
Contaminants	**Concentration**	**Qualifiers out of Control**
Nitrate	*	Benzo(a)pyrene
Flouride	*	1,1-Dichloroethylene
Sulfate	*	Chloroform
Chloride	*	1,1,1-Trichloroethane
Iron	1.08 mg/L	Carbon Tetrachloride
Sodium	41.7 mg/L	Benzene
Potassium	1.5 mg/L	1,2-Dichloroethane
Manganese	0.12 mg/L	Trichloroethylene
Aluminum	0.06 mg/L	Bromodichloromethane
Gross alpha activity	2 pCi/L	1,1,2-Trichloroethane
		Chlorodibromomethane
		Ethylbenzene
		m & p-Xylene
		o-Dichlorobenzene

* - results pending from OPH Central Lab Reports

Table 21. Contaminants Found in Region 5 Water as Reported by OPH Central Labs

Region 5		
Contaminants	**Concentration**	**Qualifiers out of Control**
Flouride	0.1 mg/L	Dalapon
Sulfate	2 mg/L	Picloram
Chloride	138.6 mg/L	Endrin
Iron	1.95 mg/L	Hepatachlor epoxide
Manganese	0.46 mg/L	Hexachlorocyclopentadiene
Sodium	83.1 mg/L	Methoxychlor
Potassium	2.4 mg/L	o-Dichlorobenzene
Silver	0.01 mg/L	
1,2-Dibromoethane (EDB)	[a]	
1,2-Dibromo-3-Chloropropane (DBCP)	[a]	

[a] Compounds not tested

Table 22. Contaminants Found in Region 6 Water as Reported by OPH Central Labs

Region 6		
Contaminants	**Concentration**	**Qualifiers out of Control**
Nitrate	0	Bis (2-Ethylhexyl) Phthalate
Flouride	1.1 mg/L	Benzo(a)pyrene
Sulfate	less than	Methoxychlor
Chloride	13.0 mg/L	Hexachlorocyclopentadiene
Iron	0.05 mg/L	Endothall
Sodium	90.8 mg/L	Tetrachloroethylene
Potassium	2.1 mg/L	Bromoform
Manganeese	0.01 mg/L	o-Dichlorobenzene
Aluminum	0.03 mg/L	

Table 23. Contaminants Found in Region 7 Water as Reported by OPH Central Labs

Region 7		
Contaminants	**Concentration**	**Qualifiers out of Control**
Nitrate	0	Bis (2-Ethylhexyl) Phthalate
Flouride	0.8 mg/L	Benzo(a)pyrene
Sulfate	43 mg/L as SO4	Methoxychlor
Chloride	27.1 mg/L	Hexachlorocyclopentadiene
Iron	0.07 mg/L	Endothall
Sodium	26.6 mg/L	Tetrachloroethylene

(Table 23 continued)

Potassium	2.2 mg/L	Bromoform
Manganese	0.01 mg/L	o-Dichlorobenzene
Aluminum	0.08 mg/L	
Chloroform	6.5 µg/L	
Bromodichloromethane	2.7 µg/L	
Chlorodibromomethane	1.1 µg/L	

Table 24. Contaminants Found in Region 8 Water as Reported by OPH Central Labs

Region 8		
Contaminants	**Concentration**	**Qualifiers out of Control**
Bis (2-Ethylhexyl) Phthalate	2.29 µg/L	Benzo(a)pyrene

Table 25. Contaminants Found in Region 9 Water as Reported by OPH Central Labs

Region 9
Qualifiers out of Control
p-Dichlorobenzene
o-Dichlorobenzene
1,2,4-Trichlorobenzene

Toward the end of this testing, it was ascertained that to obtain inhibition data about the method blank samples, HPLC grade DI water should have been analyzed as a sample in some position other than the first in the analysis set. Unfortunately, adequate amounts of reagent were not available to perform these tests.

CHLORINE TEST

Chlorine content was measured, using the provided Checkit, on water samples from Regions 3, 6, and 7. These were the only regional water samples tested as there were only three chlorine tabs available for testing. These three regions all use chlorination as a disinfection method at their facility. It is noted in the operating manual

for the ECLOX-M™ that other disinfecting chemicals such as bromine, iodine, and higher valence manganese also react to the chlorine test (38). The operating manual also states that if chlorine content is more than 0.4 mg/L, then two drops of pre-conditioner reagent (provided with the kit) should be added to the water sample before testing in the luminometer. There were no water samples tested that contained chlorine content over 0.4 mg/L (see Table 26). Region 3, 6 and 7 reported chloride content of 34.2 ppm, 13 ppm, and 27.1 ppm, respectively from the OPH Central Lab reports (See Appendices F, I & J respectively). There has been no correlation detected between chloride content and the Checkit's ability to detect chlorine content.

Table 26. Chlorine Content on Regions 3, 6, & 7 Water Samples

OPH Region	Chlorine Content (mg/L)
3	<0.2
6	0.0
7	<0.2

pH

pH was analyzed on all regional water samples using the provided pH meter in the ECLOX-M™ kit. Each water sample was tested approximately 4 times and the average was calculated and compared to the average pH obtained from the OPH Central Lab Reports (see Table 27 and Figures 17 and 18). OPH Central Labs were not able to provide pH data on all water samples. A one-way analysis of variance revealed that there was a significant difference between the pH for the regional water samples ($p \leq 0.01$). However, the pH results were not significantly different between the ECLOX-M™ readings and those from the OPH Central Labs ($p \geq 0.5$).

Table 27. Comparison of pH Results for All Regional Water Samples

	ECLOX-M™ Results		OPH Central Lab	
OPH Region	**Average pH**	**Standard Deviation (%)**	**Reported pH**	**(%) Difference**
1	8.5	0.3	8.47	0.8%
2	8.7	0.1	*	*
3	7.9	0.2	7.59	4.4%
4	7.7	0.3	7.72	0.3%
5	7.8	0.2	7.07	9.4%
6	8.1	0.3	7.52	6.9%
7	8.6	0.4	9.04	4.8%
8	8.0	0.3	*	*
9	8.1	0.2	*	*

*** No pH results reported from OPH Central Labs.**

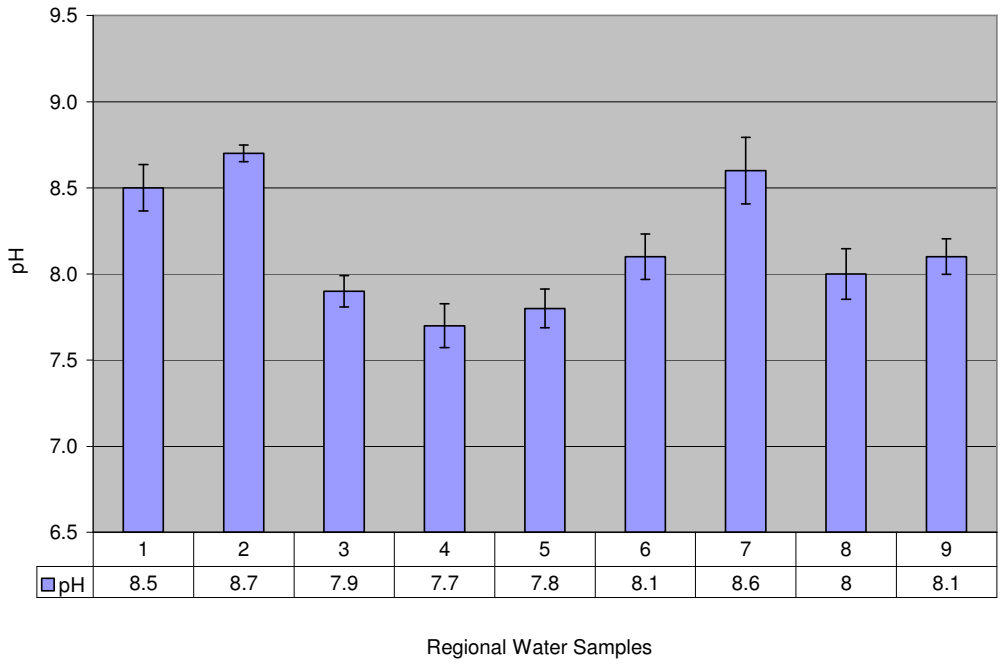


Figure 17. Average pH Values for all OPH Regions taken by the ECLOX-M™ pH Meter.

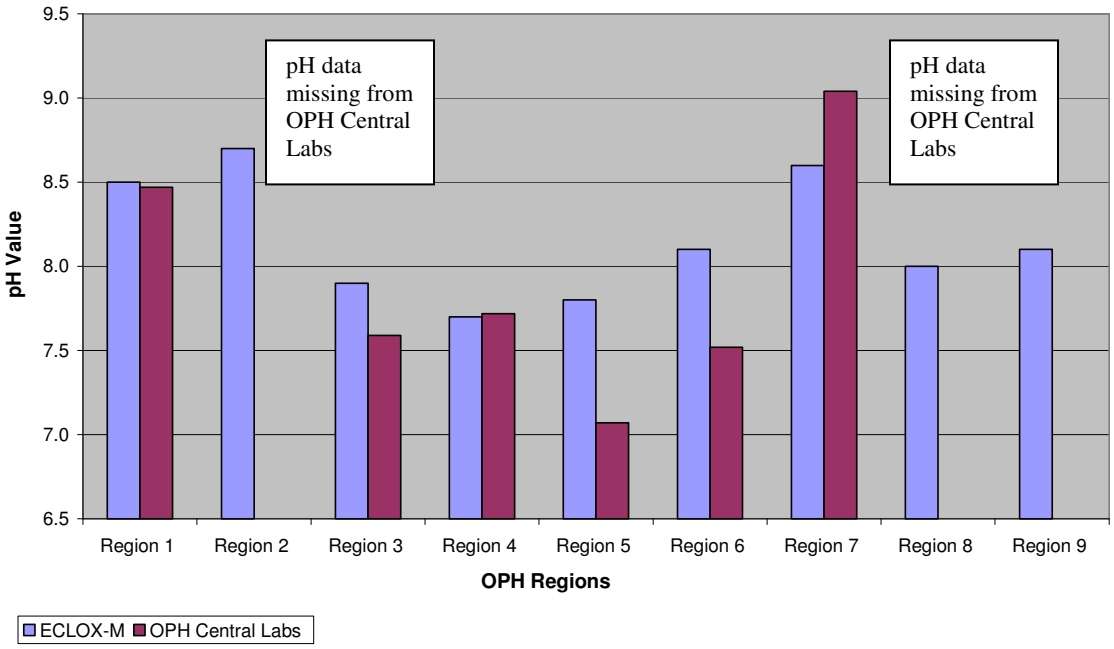


Figure 18. Comparison of pH Values between the ECLOX-M™ and the OPH Central Lab Reports.

CHEMICAL STANDARDS AND CHEMICAL MIXTURES

Chemical standards and chemical mixtures were tested with the ECLOX-M™ for chemiluminescence. The chemicals that were analyzed by the ECLOX-M™ resulted in percent inhibition data that varied considerably among chemicals (See Figure 19). The percent inhibitions for mercury, the regulated pesticide mixture, and the volatile liquid mixture standards were found to be significantly different from the high concentrations to the low concentrations tested ($p \leq 0.01$) (See Tables 28, 30, and 31). A one-way analysis of variance revealed that there was a significant difference in percent inhibition data for the volatile gas mixture at 100 ppm, 50 ppm and 5 ppm ($p \leq 0.01$) (See Table 32). A one-way analysis of variance also revealed that there was a significant difference in percent inhibition data for the atrazine standard at 30ppm and 3 pm ($p \leq 0.01$) (See Table 29).

Table 28. Mercury Percent Inhibition Results

Concentration (mg/L)	Inhibition (%)			Average (%)	Standard Deviation
20	100	100	98	97	6
	97	98	99		
	99	99	97		
	98	98	99		
	97	99	100		
	99	79			
	100	78			
2	32	1	2	9	14
	9	6	21		
	13	4	33		
	35	-3	20		
	0	-18	21		
	1	3	3		
	-14	93*	18		
	9	-1			

* data point out of character, not included in average or other statistical analysis

Table 29. Atrazine Percent Inhibition Results

Concentration (mg/L)	Inhibition (%)	Average (%)	Standard Deviation (%)
30	40	42	8
	44		
	51		
	51		
	35		
	32		
3	-1	11	13
	-3		
	-9		
	21		
	94*		
	27		

* data point out of character, not included in average or other statistical analysis

Table 30. Regulated Pesticide Mixture Percent Inhibition Results

Concentration (mg/L)	Inhibition (%)	Average (%)	Standard Deviation
40	99 95 96 99 99 96	97	2
4	23 71 7 21 79 -23	30	39

Table 31. Volatile Liquid Mixture Percent Inhibition Results

Concentration (mg/L)	Inhibition (%)	Average (%)	Standard Deviation
50	92 87 91 87 93 90	90	3
5	42 44 43 32 36 40	40	5

Table 32. Volatile Gas Mixture Percent Inhibition Results

Concentration (mg/L)	Inhibition (%)	Average (%)	Standard Deviation
100	50 60 57 58	56	4
50	37 25 36	33	7
5	3 2 8 19 14 37	14	13

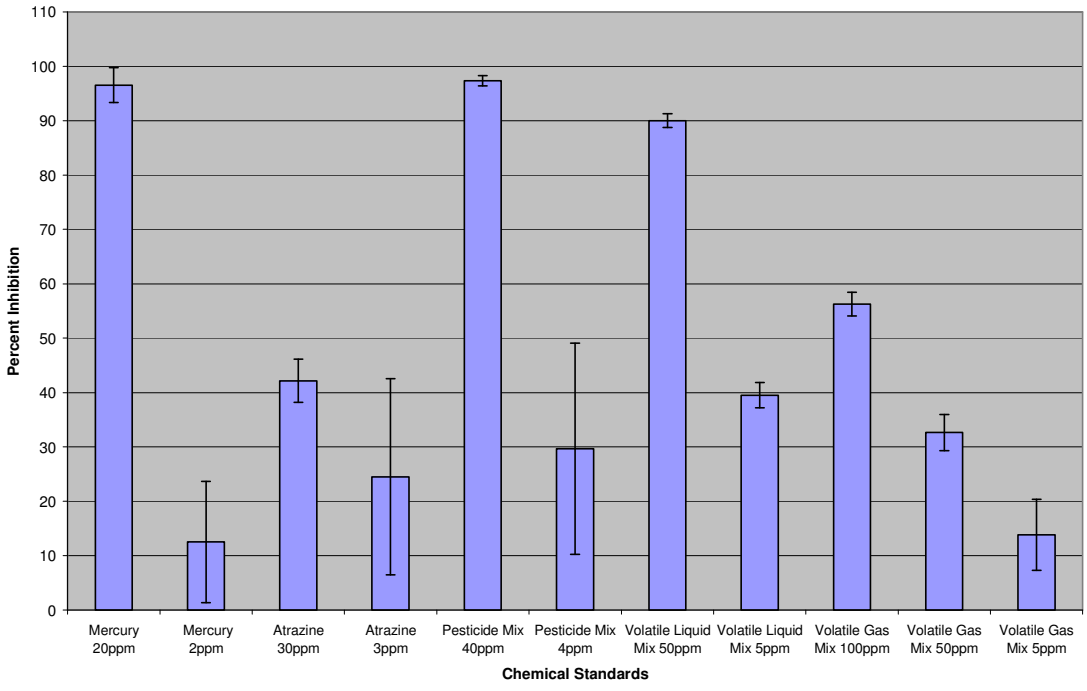


Figure 19. Chemical Standards and Chemical Mixtures Percent Inhibition Data

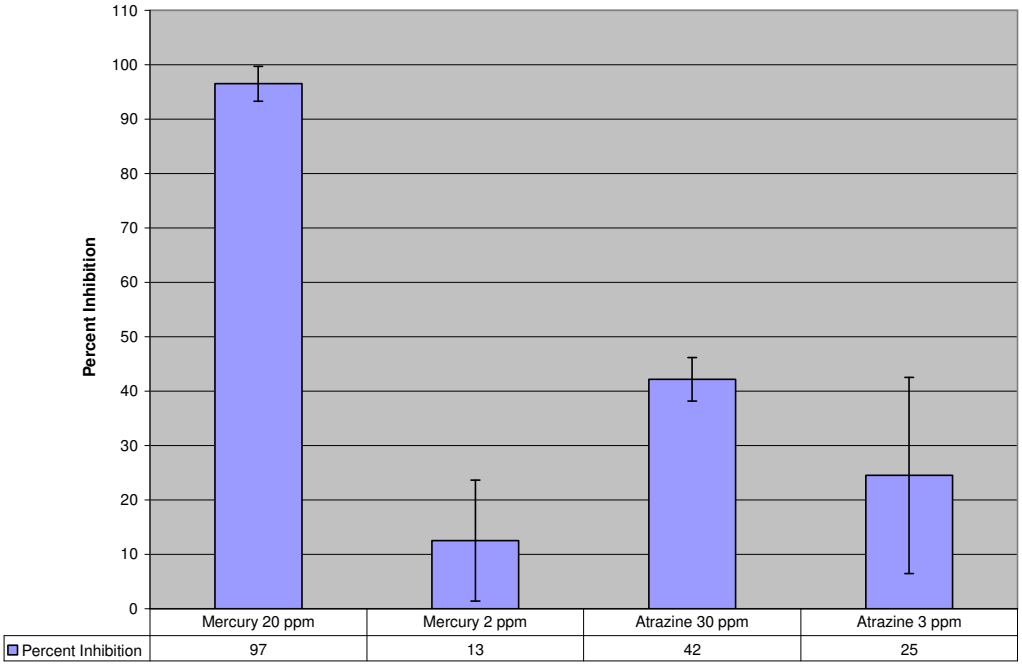


Figure 20. Chemical Standards Average Percent Inhibition

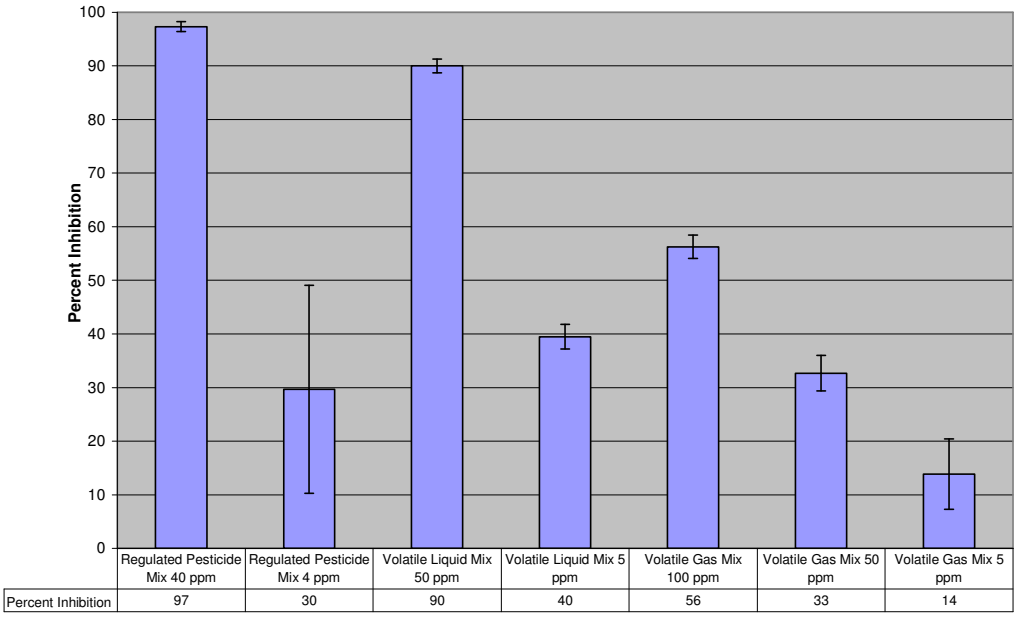


Figure 21. Chemical Standard Mixtures Average Percent Inhibition

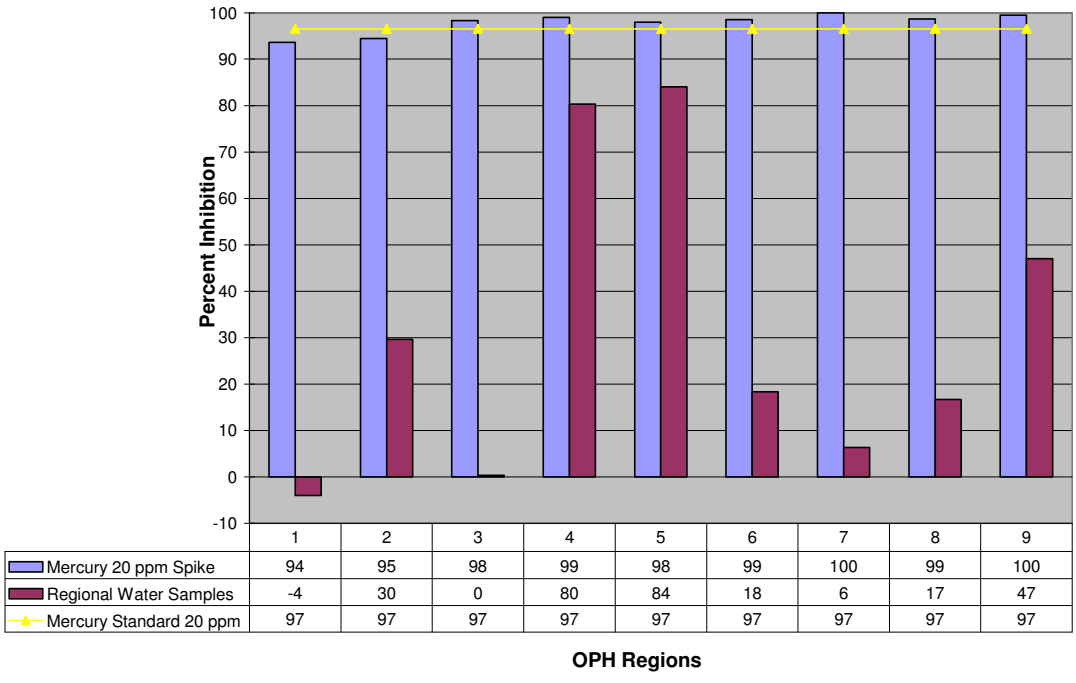
SPIKED SAMPLES

All spiked water samples were prepared with unspiked regional drinking water. The percent inhibition seen was compared with the average percent inhibition for that regions drinking water samples, in addition to the average percent inhibition data of the chemical standard or chemical mixture. The previous testing for the regional water sample percent inhibition was crucial. The ability of the ECLOX-M™ to detect toxicity is dependent on the light production of the ECLOX-M™ reagents in a clean drinking water matrix. If clean water produces 100% inhibition of light, the detection of subsequently added contaminants would not be possible. Furthermore, if the water sample produces any inhibition of light at all, a chemical spike would make it difficult to ascertain whether inhibition was caused by the added chemical, or due to an interaction between the background contaminants and the added spike chemical. For example, for the mercury chemical analysis, since the percent inhibition for water samples in regions 4, 5 and 9 are so high (80, 84, and 47 respectively), this suggests that background chemicals could be interfering with added spiked chemicals, and not giving accurate results.

A response was considered a false positive if an unspiked drinking water sample produced inhibitions significantly greater than zero, or greater than the HPLC grade de-ionized water method blank. In other words, a false positive would occur if unspiked drinking water samples produced an inhibition such that the addition of toxic contaminants could not be detected. Depending on the degree of inhibition in the water sample, toxicity due to subsequent contamination of that sample may not be detectable or could be exaggerated as a result of the baseline inhibition. In these experiments water

samples from Regions 4, 5 & 9 were considered false positives. A response was considered a false negative when a water sample was spiked with a known concentration of contaminant and the percent inhibition did not indicate a result significantly greater than the water sample percent inhibition.

Figures 22 and 23 show the comparison between the average regional water sample percent inhibition, the 20 or 2 ppm mercury spiked water sample, and the average percent inhibition for the chemical standard. The inhibition induced by mercury spikes at 20 ppm show an additive effect on the water samples with no results significantly different than the chemical standard at 97 %. The 2 ppm mercury spikes show an inhibitory effect on Region 2, 8 & 9 water samples (the resulting inhibition was lower for the spiked sample than for the water sample itself).



	1	2	3	4	5	6	7	8	9
Mercury 20 ppm Spike	94	95	98	99	98	99	100	99	100
Regional Water Samples	-4	30	0	80	84	18	6	17	47
Mercury Standard 20 ppm	97	97	97	97	97	97	97	97	97

Figure 22. Regional Water Samples vs. Spiked Samples with 20 ppm Mercury

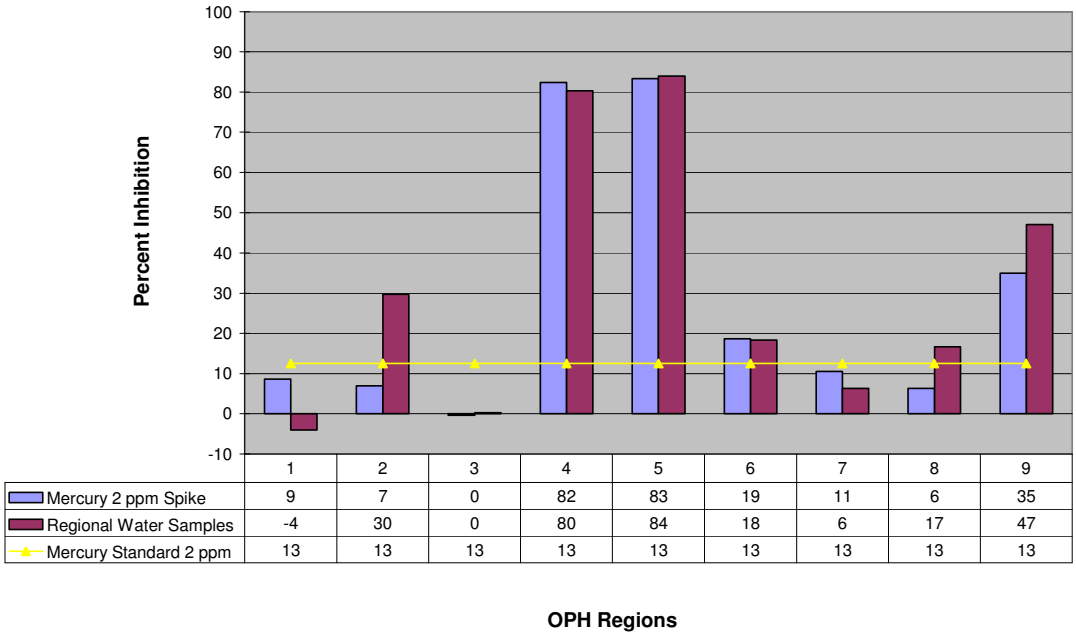
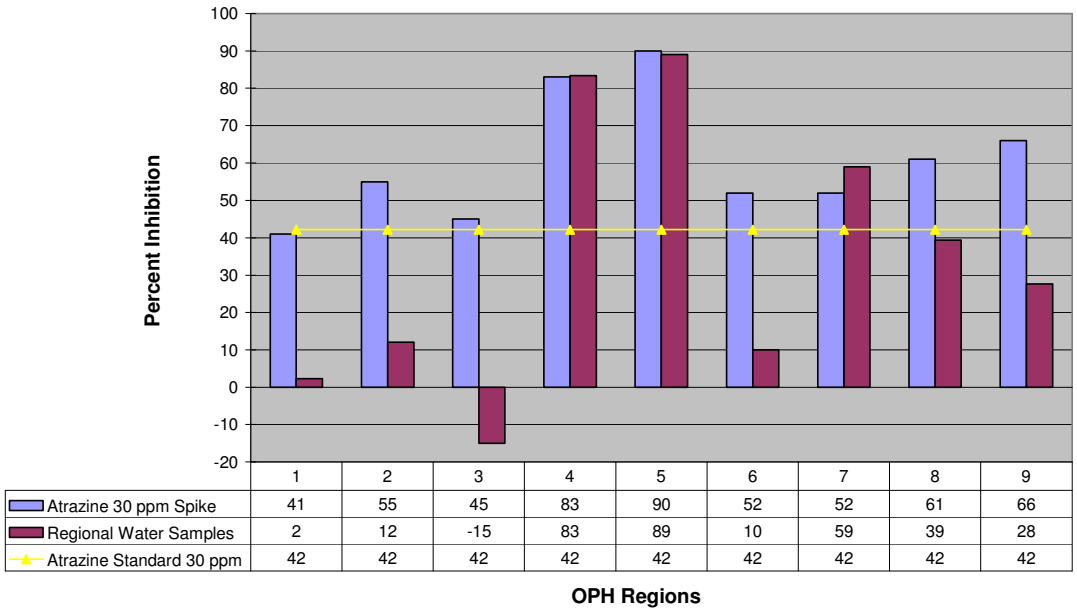


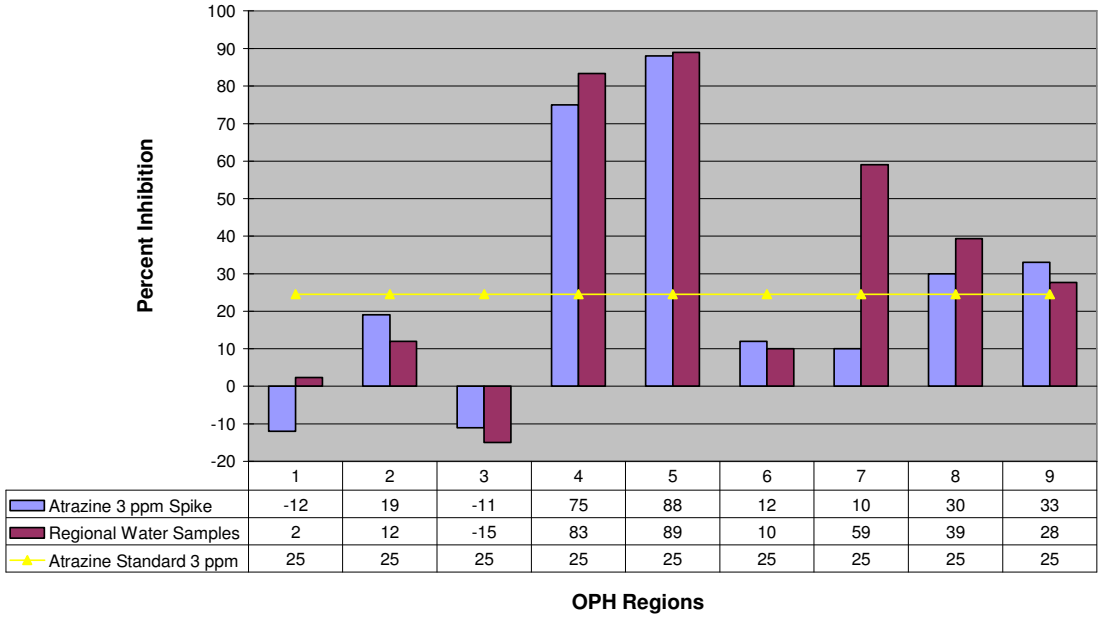
Figure 23. Regional Water Samples vs. Spiked Samples with 2 ppm Mercury

Figures 24 and 25 show the comparison between the average regional water sample percent inhibition, the 30 or 3 ppm atrazine spiked water sample, and the average percent inhibition for the chemical standard. False positive results were recorded for water samples at regions 4, 5, 7, & 8. The Region 7 sample is the only 30 ppm atrazine spiked sample in which an inhibitory effect was seen, not additive, after the spike. The 3 ppm atrazine spikes show an inhibitory effect for regions 1, 4, 5, 7, & 8. The resulting inhibition was lower for the spiked sample than for the water sample itself. Regions 2,3,6 & 9 showed additive effects as predicted.



	1	2	3	4	5	6	7	8	9
Atrazine 30 ppm Spike	41	55	45	83	90	52	52	61	66
Regional Water Samples	2	12	-15	83	89	10	59	39	28
Atrazine Standard 30 ppm	42	42	42	42	42	42	42	42	42

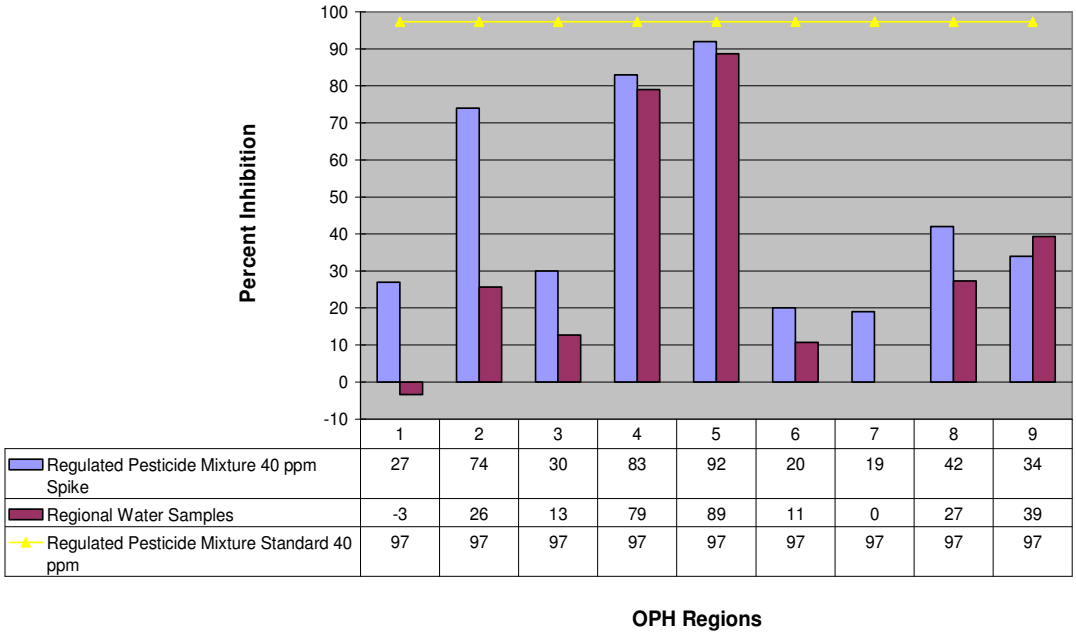
Figure 24. Regional Water Samples vs. Spiked Samples with 30 ppm Atrazine



	1	2	3	4	5	6	7	8	9
Atrazine 3 ppm Spike	-12	19	-11	75	88	12	10	30	33
Regional Water Samples	2	12	-15	83	89	10	59	39	28
Atrazine Standard 3 ppm	25	25	25	25	25	25	25	25	25

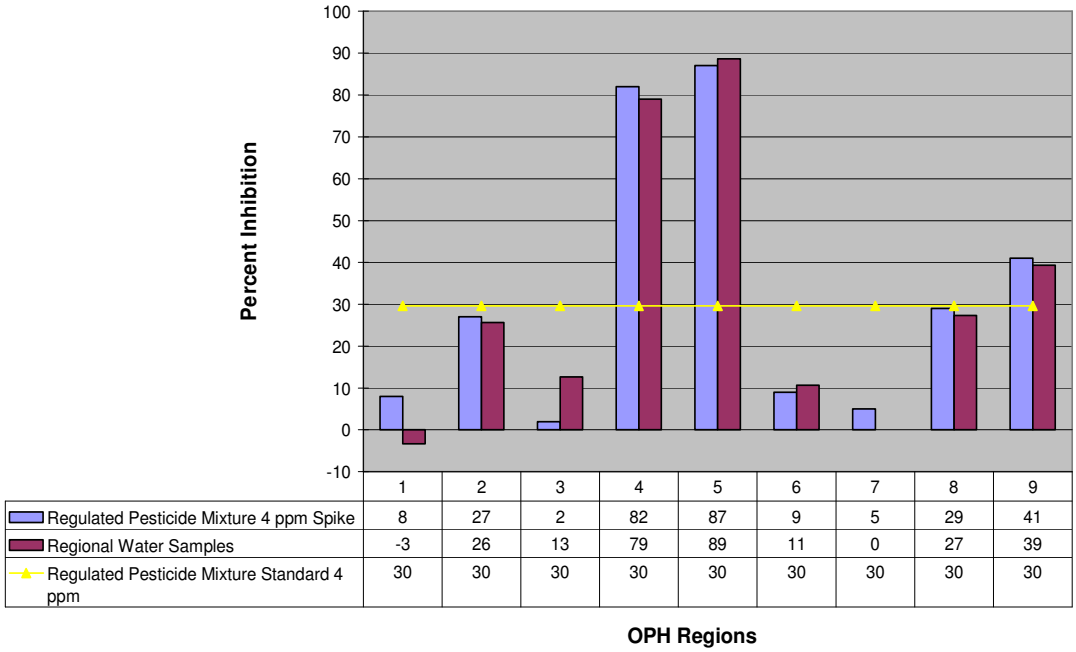
Figure 25. Regional Water Samples vs. Spiked Samples with 3 ppm Atrazine

Figures 26 and 27 show the comparison between the average regional water sample percent inhibition, the 40 or 4 ppm regulated pesticide mixture spiked water samples, and the average percent inhibition for the chemical standard. False positive results were recorded for water samples at regions 4, 5, & 9. The Region 9 sample is the only 40 ppm regulated pesticide mixture spiked sample in which an inhibitory effect was seen, not additive, after the spike. The 4 ppm regulated pesticide mixture spikes show an inhibitory effect for regions 3, 5 & 6. The resulting inhibition was lower for the spiked sample than for the water sample itself. All other regions showed additive effects as predicted.



	1	2	3	4	5	6	7	8	9
Regulated Pesticide Mixture 40 ppm Spike	27	74	30	83	92	20	19	42	34
Regional Water Samples	-3	26	13	79	89	11	0	27	39
Regulated Pesticide Mixture Standard 40 ppm	97	97	97	97	97	97	97	97	97

Figure 26. Regional Water Samples vs. Spiked Samples with 40 ppm Regulated Pesticide Mixture

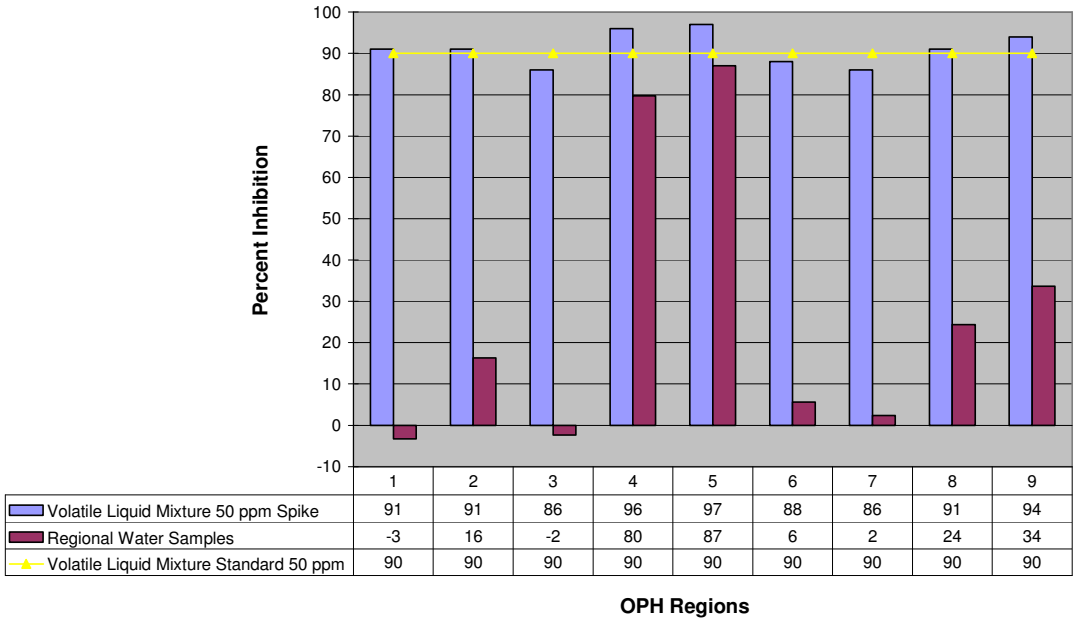


	1	2	3	4	5	6	7	8	9
Regulated Pesticide Mixture 4 ppm Spike	8	27	2	82	87	9	5	29	41
Regional Water Samples	-3	26	13	79	89	11	0	27	39
Regulated Pesticide Mixture Standard 4 ppm	30	30	30	30	30	30	30	30	30

Figure 27. Regional Water Samples vs. Spiked Samples with 4 ppm Regulated Pesticide Mixture

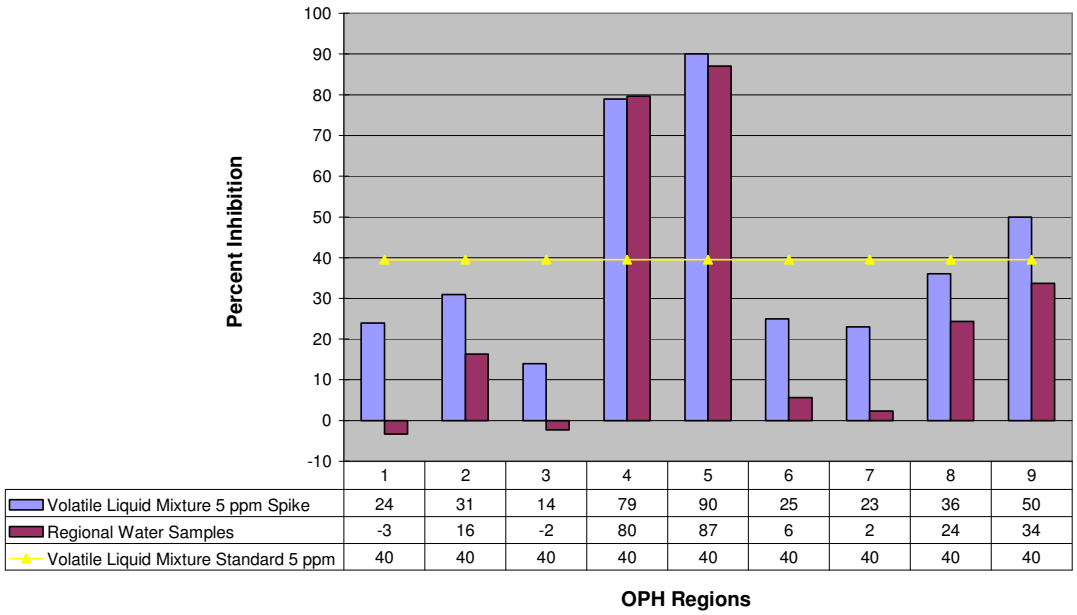
Figures 28 and 29 show the comparison between the average regional water sample percent inhibition, the 50 or 5 ppm volatile liquid mixture spiked water sample, and the average percent inhibition for the chemical standard. False positive results were recorded for water samples at region 4, 5, & 9. No inhibitory results were seen for the 50 ppm or the 5 ppm spikes, only additive effects as predicted.

Figures 30 and 31 show the comparison between the average regional water sample percent inhibition, the 100 or 5 ppm volatile gas mixture spiked water samples, and the average percent inhibition for the chemical standard. False positive results were recorded for water samples at regions 4, 5, & 9. A 100 ppm spike was not conducted on Region 9 water, as there was not sufficient reagent to run this test.



	1	2	3	4	5	6	7	8	9
Volatile Liquid Mixture 50 ppm Spike	91	91	86	96	97	88	86	91	94
Regional Water Samples	-3	16	-2	80	87	6	2	24	34
Volatile Liquid Mixture Standard 50 ppm	90	90	90	90	90	90	90	90	90

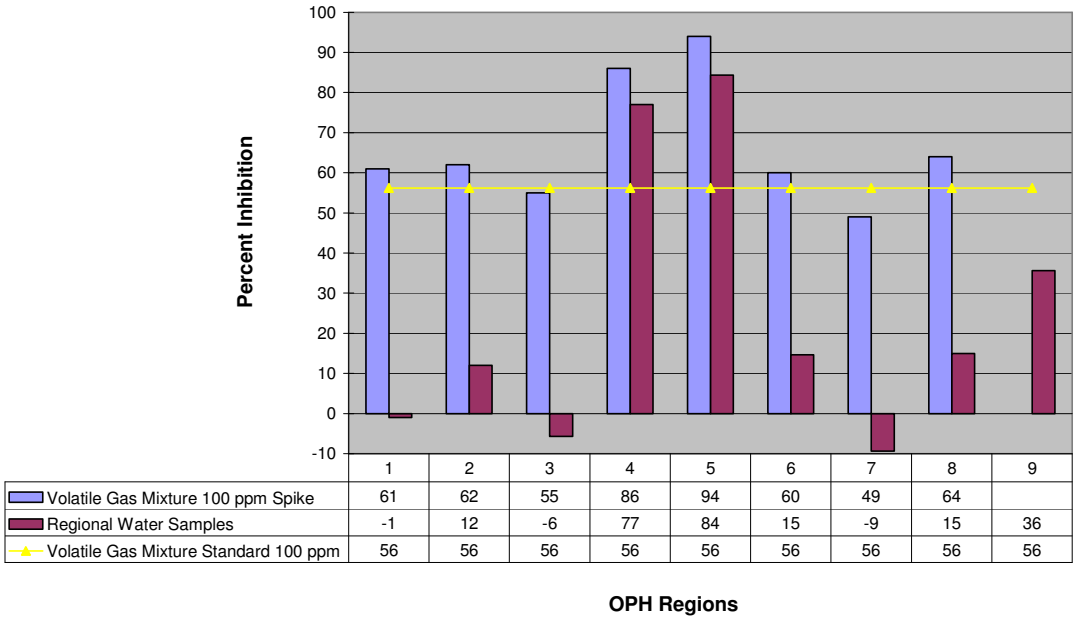
Figure 28. Regional Water Samples vs. Spiked Samples with 50 ppm Volatile Liquid Mixture



	1	2	3	4	5	6	7	8	9
Volatile Liquid Mixture 5 ppm Spike	24	31	14	79	90	25	23	36	50
Regional Water Samples	-3	16	-2	80	87	6	2	24	34
Volatile Liquid Mixture Standard 5 ppm	40	40	40	40	40	40	40	40	40

Figure 29. Regional Water Samples vs. Spiked Samples with 5 ppm Volatile Liquid Mixture

No inhibitory results were seen for the 100 ppm spikes, only additive effects as predicted. The 5 ppm spiked samples show an inhibitory effect for regions 1, 2, 7, 8, & 9. The resulting inhibition was lower for the spiked sample than for the water sample itself. All other regions showed additive effects as predicted.

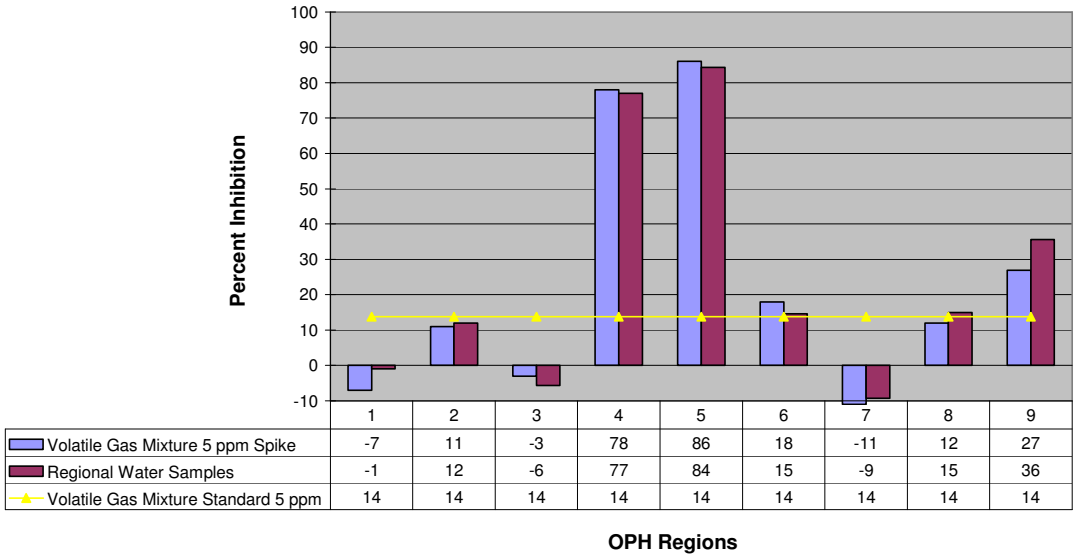


	1	2	3	4	5	6	7	8	9
Volatile Gas Mixture 100 ppm Spike	61	62	55	86	94	60	49	64	
Regional Water Samples	-1	12	-6	77	84	15	-9	15	36
Volatile Gas Mixture Standard 100 ppm	56	56	56	56	56	56	56	56	56

Figure 30. Regional Water Samples vs. Spiked Samples with 100 ppm Volatile Gas Mixture

MIXTURES OF CHEMICALS

A metal mixture was prepared containing mercury at 2 ppm, lead at 15 ppm, and atrazine at 3 ppm. The mixture was analyzed for both interactions between the chemicals, and the ECLOX-M™s ability to detect these interactions from the mixture. It was hypothesized that an additive effect would be seen from the mixture of the three chemical standards. Therefore, the three chemical standards' average percent inhibitions



	1	2	3	4	5	6	7	8	9
Volatile Gas Mixture 5 ppm Spike	-7	11	-3	78	86	18	-11	12	27
Regional Water Samples	-1	12	-6	77	84	15	-9	15	36
Volatile Gas Mixture Standard 5 ppm	14	14	14	14	14	14	14	14	14

Figure 31. Regional Water Samples vs. Spiked Samples with 5 ppm Volatile Gas Mixture

(9, 29, and 13 respectively) were added resulting in a 51percent inhibition. This was the predicted inhibition percent. The test revealed an average inhibition percent of 29%, a 57% decrease from the prediction (See Figure 32). This suggests that the chemical standard mix had an inhibitory effect on the ECLOX-M™ reagents. The average percent inhibition for the mixture was exactly the same as that for the lead, 15 ppm, chemical standard.

A volatile mixture was prepared containing the regulated pesticide mix at 4 ppm, the volatile liquid mix at 5 ppm, and the volatile gas mix at 5 ppm. It was hypothesized that an additive effect would be seen from the mixture of the three chemical standard mixtures. Therefore, the three chemical standard mixtures' average percent inhibitions (17, 30 and 9 respectively) were added resulting in a 56 percent inhibition. This was the predicted inhibition percent. The test revealed an average inhibition percent of 99%, a

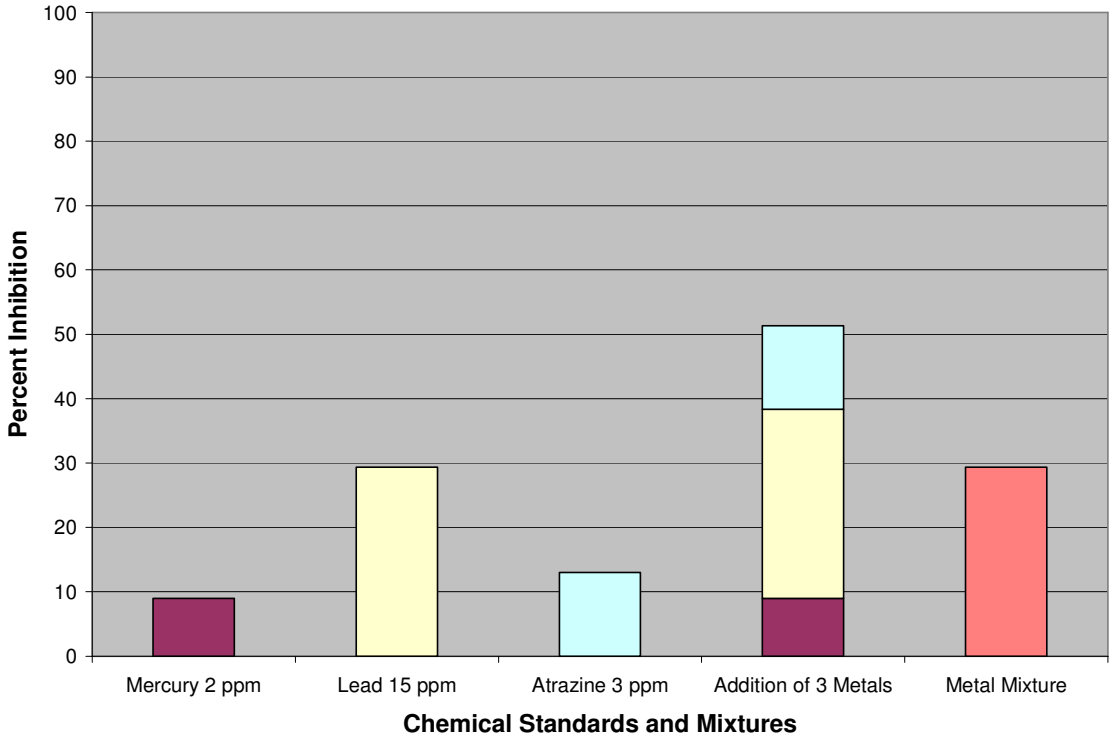


Figure 32. Comparison of Metal Standards and Metal Mixture with Percent Light Inhibition

57% increase over the prediction (See Figure 33). This suggests that the mixture had a synergistic effect on the ECLOX-M™ reagents.

Nerve Agent/Pesticide

Nerve Agent/Pesticide tests were run for both atrazine standards and regulated pesticide mixtures, in addition to regional water samples and HPLC grade de-ionized water. The test strips showed a positive reading for the regulated pesticide mixture at 40 ppm and 4 ppm, but not for the herbicide atrazine at 30 ppm or 3 ppm (See Table 33). Test strips have a limit of detection of 0.1-5 ppm for carbamates, 0.5-5 ppm for thiophosphates and 1-5 ppm for organophosphates (See Appendix C).

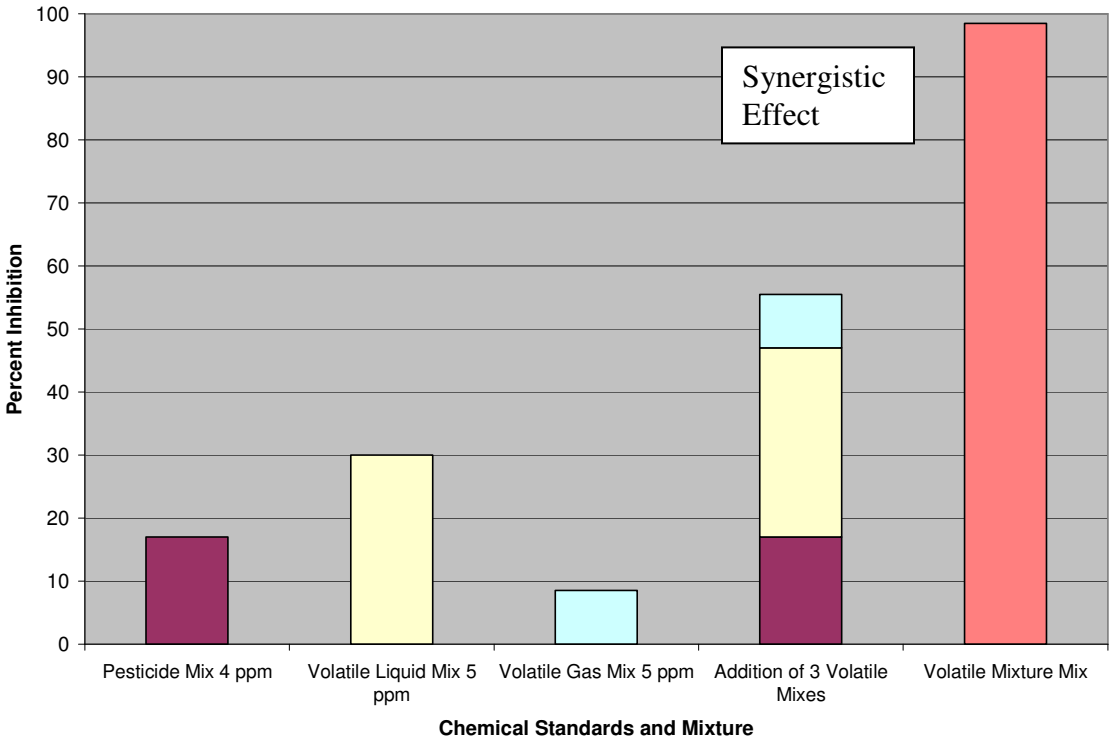


Figure 33. Comparison of Chemical Standards and Volatile Mixture with Percent Inhibition

Table 33. Pesticide Test Strips Results on Chemical Standards and Regional Water Samples

Description	Disk Color	Threat	Result
Atrazine 30 ppm	Blue	No Threat	Negative
Atrazine 3 ppm	Blue	No Threat	Negative
Pesticide Mix 40 ppm	White and pink	Definite threat	Positive
Pesticide Mix 4 ppm	White and pink	Definite threat	Positive
Region 7 Water Sample	Blue	No Threat	Negative
Region 8 Water Sample	Blue	No Threat	Negative
Region 9 Water Sample	Blue	No Threat	Negative
HPLC Grade DI Water	Blue	No Threat	Negative

Arsenic

The arsenic test was run with regional water samples, heavy metal chemical standards and a 1,000 ppm standard of arsenic provided by OPH Central Labs. The test results show that the arsenic test was not sensitive to other heavy metal chemicals, and only slightly sensitive to the 1,000 ppm Arsenic chemical standard (See Table 34). Arsenic Reagent 1 provided with the kit was expired on November 2003, 5 months before use for this experiment. The expired reagent probably lost its sensitivity and therefore could not give a detection of the 1,000 ppm Arsenic chemical standard at a higher level. Normal limit of detection is from 0-4 mg/L.

Table 34. Arsenic Test Results

Description	Arsenic Value
DI Water	0 mg/L
Region 2 Water Sample	0 mg/L
Region 6 Water Sample	0 mg/L
Region 7 Water Sample	0 mg/L
Region 9 Water Sample	0 mg/L
Mercury 20 ppm	0 mg/L
Mercury 2 ppm	0 mg/L
Lead 150 ppm	0mg/L
Chromium 100 ppm	0 mg/L
Arsenic 1000 ppm	b/n 0.1-0.6mg/L

SIMULTANEOUS TESTING OF SDWP AND REGION 2 ECLOX-M™ MACHINES

Two ECLOX-M™ machines (SDWP and Region 1) were tested simultaneously with chemical standards and chemical mixtures to check for variability between the two systems. Each machine was tested with all the chemical standards including an extra standard of lead at 150 and 15 ppm, supplied by OPH Central Labs. Chemical standard

analysis on lead was not conducted during the other experiments due to limited reagent supplies. Therefore, the results for lead are only reported to determine variability between the two ECLOX-M™ machines. Using a one-way analysis of variance revealed that the data comparison between the two machines was not significantly different ($p \geq 0.9$). Also, the percent inhibition of the chemical standards on both the Region 2 and SDWP ECLOX-M™ were not significantly different than the average inhibition of the chemical standards from earlier analysis ($p \geq 0.6$ and $p \geq 0.3$ respectively). The only noticeable difference was in the percent inhibition for the chemical standard of Atrazine at 30 ppm (42 percent), which was significantly different than the percent inhibition seen for the standard on both the Region 2 and SDWP ECLOX-M™ (99 and 99 percent respectively) ($p \leq 0.01$). Summarized Tables and Figures illustrating results and comparisons are following (See Table 35 and Figure 34).

Table 35. Percent Inhibition of Chemical Standards Tested on the Region 2 and the SDWP ECLOX-M™ Simultaneously.

Chemical Standard	**Average Inhibition (%)**	**Region 2 ECLOX-M™ (%)**	**SDWP ECLOX-M™ (%)**	**(%) Difference**
Mercury 20 ppm	97	95	100	5
Mercury 2 ppm	9	-4	2	150
Atrazine 30 ppm	42	99	99	0
Atrazine 3 ppm	11	11	14	27
Pesticide Mix 40 ppm	97	99	99	0
Pesticide Mix 4 ppm	30	24	30	25
Volatile Liquid Mix 50 ppm	90	89	93	4
Volatile Liquid Mix 5 ppm	40	36	37	3

(Table 35 continued)

Volatile Gas Mix 50 ppm	33	36	35	3
Volatile Gas Mix 5 ppm	14	9	8	11
Lead 150 ppm	*	100	100	0
Lead 15 ppm	*	25	27	8

* Average percent inhibition data not available for these standards

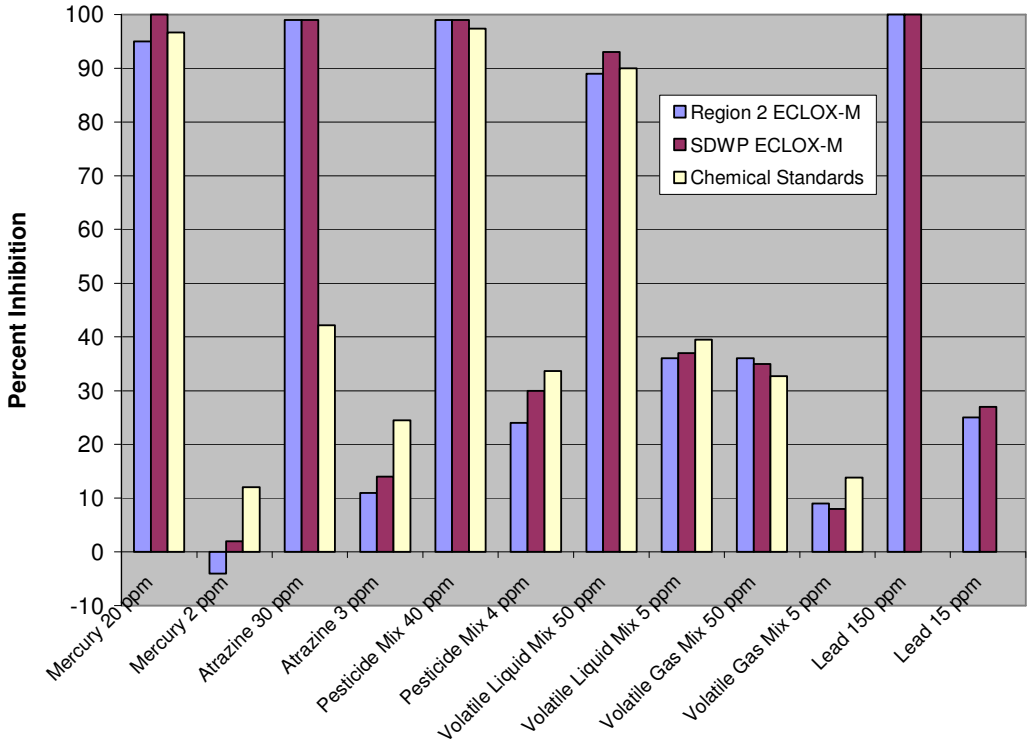


Figure 34. Simultaneous Run Between the Region 2 and SDWP ECLOX-M™ Machines.

SUMMARY AND CONCLUSIONS

With any test method it is important to understand what the output and response of the equipment is measuring (i.e. contamination), and its potential environmental consequences. It is also important to have quality assurance tests run on the technology to evaluate its overall performance and to assess and select appropriate methods for its use. This is the first of such internal quality assurance tests performed on this system.

Severn Trent's ECLOX-M™ system provides an easy to use, rapid detection of water quality, which is cost-effective and repeatable. It is a very easy surveillance system to use, the procedures are straightforward, and the instructions are detailed and easy to understand.

The chemiluminescence test has the capability of detecting substances with different modes of toxic action such as: polar narcotics, respiratory blockers, oxidative uncouplers, membrane irritants, cholinesterase inhibitors, CNS convulsants, heavy metals, photosynthetic inhibitors, and cell division inhibitors (See Appendix B). The system however is not without its limitations. NPDWR MCL limits for some of the chemicals are on the order of 100 to 1,000 times lower than the limits of detection for the unit. Therefore the unit is not acceptable for determining if water is USEPA drinking water quality. Also, disinfection procedures such as chlorination can interfere with the chemiluminescence reaction because free chlorine inhibits light production and can degrade contaminants if water samples are stored. The USEPA ETV reports have found that the luminometer is sensitive to waters which have a high biological oxygen demand (BOD) and chemical oxygen demand (COD), even if the actual toxicity on the organism is low.

The ETV research and development reports suggest that the ECLOX-M™ is a good measure of environmental quality in tracing point sources of pollution, and in tracking changes in water quality (16). It finds that the system is insensitive to some contaminants, yet sensitive to others such as inorganic salts and urea. These do not cause toxicity to higher organisms (at environmentally relevant concentrations), but they do produce results in the chemiluminescence reaction. Since the test is not to be used for a toxicity measurement, one should follow up these tests with more specific testing methods for identification and to determine what the biological and environmental consequences will be.

Water samples tested with the ECLOX-M™ resulted in varying levels of reagent inhibition. The variations depended on the kind of water system they derived from, what the source water was, the type of disinfection processes used at the facility, and contaminants found in the samples from OPH Central Lab Reports. Regions 1 and 3 were surface water systems that used the Mississippi River as source water and chlorination for disinfection. These two regions were considered having the cleanest water due to their average percent inhibitions closest to zero (-2% and -2% respectively), despite having trace amounts of various ions found from OPH Central Lab analysis (Tables 17 & 19 and Appendices D & F). As stated before, the negative percent inhibition seen is a result of an increase in light production by the enzyme relative to the HPLC grade de-ionized water method blank.

Regions 4 and 5 on the other hand were considered the worst in water quality from analysis with the ECLOX-M™. They had average inhibition percents most significantly different from zero, 80% and 87% respectively ($p \leq 0.01$) (see Tables 21 &

22). These two regions showed the highest concentrations of the ions iron and manganese, out of all other regional water samples (See Appendices G & H). Region 5 also included high concentrations of chloride ions as well as trace amounts of silver. Although Region 9 average percent inhibition data was found to be significantly different from zero ($p \leq 0.01$), specific contamination data was not supplied from the OPH Central Labs to show inherent background interference (see Table 25 and Appendix L).

The standard deviation was measured and reported for three replicates of each regional water sample to evaluate the precision of the machine. The standard deviation of the three replicate measurements was never greater than 10 % for any regional water sample except for Region 7 at 27%.

The fact that the pH data was not significantly different between the ECLOX-M™ machine and the OPH Central Lab reports, suggests that the ECLOX-M™ pH meter is fairly accurate with a standard deviation not over 0.3% for any sample. High pH could have caused interaction between ions in the water matrix which caused less light inhibition, and also a higher standard deviation in the water sample.

Chemical standards were measured on average six times to evaluate the precision of the ECLOX-M™ for inhibition percent. Four standards were measured at different replicate intervals; mercury 20 ppm and 2 ppm as well as the volatile gas mixture 100 ppm and 50 ppm standards were measured 19, 22, 4 and 3 times respectively. The standard deviation was measured and reported for all chemical standard concentrations, and the measurement was never greater than 14% except for the regulated pesticide mixture at 4 ppm, 39%.

Chemical standards were analyzed for two concentrations each during this verification. A trend was noticed in the ECLOX-M™'s variability in reading concentrations of chemicals. The standard deviation for inhibition percent would increase as the concentration of the chemical tested would decrease. For example, the volatile gas mixture was tested at 100 ppm, 50 ppm, and 5 ppm, and the respective percent inhibition and standard deviations were 56 ±4, 33 ±7 and 14 ±13 (See Table 22). This trend was seen for all chemical standards tested. Percent inhibitions and standard deviations for mercury 20 ppm, atrazine 30 ppm, regulated pesticide mixture 50 ppm, volatile liquid mixture 50 ppm, and the volatile gas mixture 100 ppm were 97 ±6, 42 ±8, 97 ±2, 90 ±3, & 56 ±4 respectively (See Figure 35). Standard deviation was never over 8%. Inhibition percents and standard deviations for mercury at 2 ppm, atrazine at 3 ppm, regulated pesticide mixture at 5 ppm, volatile liquid mixture at 5 ppm, and the volatile gas mixture at 5 ppm were 9 ±14, 11 ±13, 30 ±39, 40 ±5 and 14 ±13 respectively (See Figure 35). James et. al (2003) report similar results that as the concentration of contaminant decreased, standard deviation of the average percent inhibition increased (23).

A trend was also seen in the ECLOX-M™'s variability in reading inhibition percent of regional water samples. As with the chemical standards, the standard deviation of inhibition percent for the regional water samples would increase as the inhibition percent of the water sample would decrease. Inhibition percents and standard deviations for water samples in Regions 1 through 9 respectively were -2 ±3, 19 ±8, -2 ±10, 80 ±2, 87 ±2, 12 ±5, 12 ±27, 25 ±10, and 37 ±7 (See Figure 36).

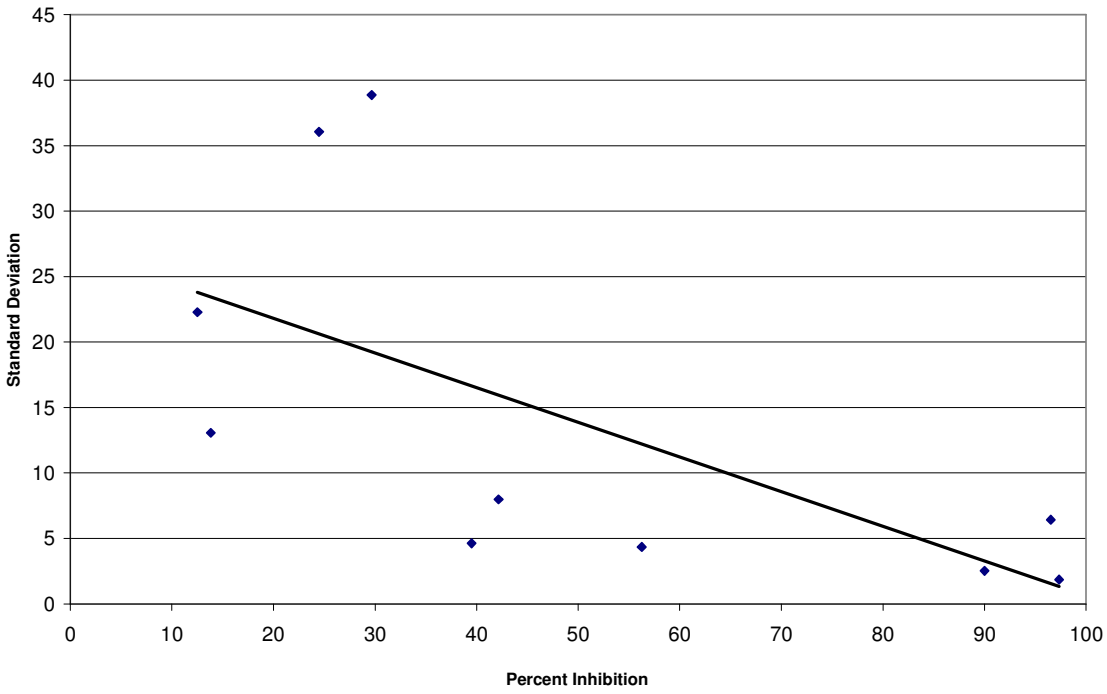


Figure 35. Trends in Chemical Standard Percent Inhibition vs. Standard Deviation

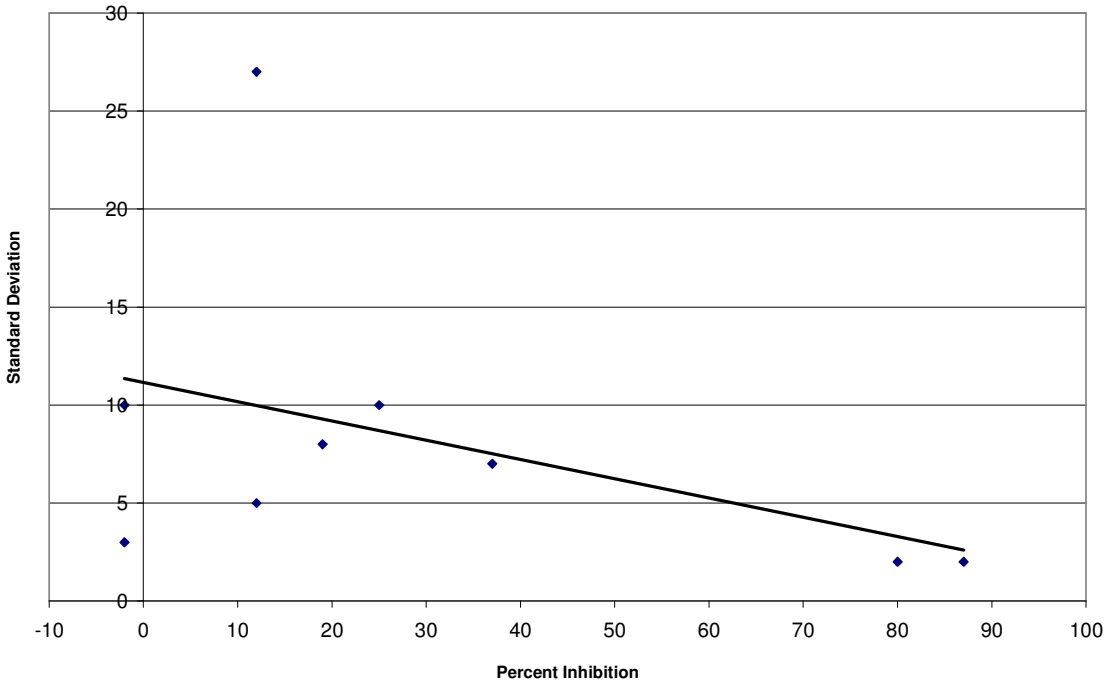


Figure 36. Trends in Regional Water Sample Percent Inhibition vs. Standard Deviation

These data show that the variability in the ECLOX-M™'s results decreased as the sample complexity increased. The higher the concentration of the contaminant, or the higher the amount of ions in the water, the lower the standard deviation was witnessed. Additional testing of chemicals with other modes of action would be recommended; such as polar narcotics, respiratory blockers, CNS convulsants, and membrane irritants. These other varieties of chemicals would help to validate the trends seen in the machine.

Spiked samples were hypothesized to result in inhibitions based on an additive effect of the chemical standard on the water sample. This was not always the case. For example, the spike of 2 ppm mercury on Region 3 water showed no effect at all. One would expect to see at least some inhibition from the addition of known concentrations of chemicals to the water.

It was more common to see inhibitory effects on chemical spikes with low concentrations. For example, 2 ppm mercury spikes on Regions 2, 8 & 9; 3 ppm atrazine spikes on Regions 1, 4, 5, 7 & 8; 4 ppm regulated pesticide mixture spikes on regions 3, 5 & 6; and 5 ppm volatile gas mixture spikes on Regions 1, 2, 7, 8 & 9, all showed inhibitory effects. Inhibitory effects were only seen on two high concentration chemical standards: the 30 ppm atrazine spike on Region 7 and the 40 ppm regulated pesticide mixture on Region 9. These inhibitory effects suggest that there was an interaction between the ions that OPH Central Labs found in the water samples, and the added chemical spikes. The high pH reported for Region 7 could be the reason for the inhibitory results on the 30 ppm and 3 ppm atrazine spike, as well as for the 5 ppm volatile gas mixture spike. Additional testing would need to be conducted on the two higher concentration spikes to further evaluate the precision of the machine and to be

certain that in these cases the result was due to interaction of ions in the water. All other spikes and water samples exhibited predicted additive effects.

Consideration in using the ECLOX-M™ needs to be taken by water systems that routinely have water containing a number of ions and/or a complex water matrix. If the system's clean water produces high light inhibition, then detection of subsequently added contaminants would be difficult to ascertain. These water systems should always follow up ECLOX-M™ testing with additional methods of contaminant detection in the event of a break in, terrorist attack, or breach in security.

There are a few generalizations that can be drawn from the results of the chemical mixtures tested. The metal mixture exhibited an average inhibition of 29% which is the same average percent inhibition for lead at 15 ppm. These results suggest that the machine is only reading the lead in the mixture and not the other two compounds. The interactions here may not be due to an inhibitory effect of the compounds on each other, as much as they are due to the machine's lowered sensitivity to a complex water matrix.

The fact that three of the chemical standards supplied for the experiments were mixtures of several components, raised further questions as to the ECLOX-M™'s ability to distinguish between individual components in a mixture, and the mixtures as a whole. It was unclear as to which component of a mixture the machine was actually reading and if interactions between components were having an effect on results. Therefore, chemical standard mixtures were tested as one large mixture to confirm that the machine cannot distinguish between the components in a mixture. The resulting synergistic effects seen from the chemical standard mixtures-mixture validates that there are interactions between the chemicals that are unknown and undetectable by the machine and the detection is out

of the machines capabilities. In order to better understand these effects, it would be beneficial to further explore the effects that single chemical components, included in some of the chemical standard mixtures, would have on inhibition percent.

A re-evaluation of the arsenic test is recommended. In order to accurately test the reagent's ability to detect arsenic in a water sample, reagents need to be kept up to date and not allowed to expire, as was the case in these experiments. Although the 1,000 ppm arsenic standard was detected with the reagents, the result of between 0.1-0.6mg/L indicates that the reagents have lost some of their sensitivity.

Lastly, the nerve agent/pesticide test was very easy to conduct and it gave an easy readout of whether or not there was contamination in the sample. Two concentrations of the triazine herbicide, atrazine, were tested to evaluate the sensitivity of the test strips to these types of chemicals. The results confirmed that the test strips were not able to detect these chemicals. Therefore one would have to rely on the chemiluminescence test or other methods to detect if drinking water was contaminated with this herbicide. The test strips had no problem in detecting the occurrence of carbamate pesticides in a mixture. The concentrations tested, 40 and 4 ppm, were well in the range of detection limits 0.1-5 ppm. This confirms that the test strips would be able to detect contamination at levels much lower than the LD50 for carbofuran, but not as low as the MCL, 0.04 ppm.

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APPENDIX A: EPA NATIONAL PRIMARY AND SECONDARY DRINKING WATER STANDARDS

EPA National Primary Drinking Water Standards

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Acrylamide	TT[8]	Nervous system or blood problems;	Added to water during sewage/wastewater increased risk of cancer treatment	zero
OC	Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R	Alpha particles	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC	Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC	Arsenic	0.010 as of 1/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes	0
IOC	Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC	Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC	Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC	Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC	Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC	Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R	Beta particles and photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP	Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC	Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC	Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC	Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D	Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes	MRDLG=4[1]

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

1

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D	Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
D	Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants & young children: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
DBP	Chlorite	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection	0.8
OC	Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC	Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC	Copper	TT[7]; Action Level = 1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M	*Cryptosporidium*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, live problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1

LEGEND

D Dinsinfectant
DBP Disinfection Byproduct
IOC Inorganic Chemical
M Microorganism
OC Organic Chemical
R Radionuclides

2

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[8]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidneys problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a
OC	Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC	Hexachlorocyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC	Lead	TT[7]; Action Level = 0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M	*Legionella*	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC	Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC	Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC	Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC	Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC	Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1

LEGEND

D Dinsinfectant
DBP Disinfection Byproduct
IOC Inorganic Chemical
M Microorganism
OC Organic Chemical
R Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC	Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories	zero
OC	Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC	Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R	Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC	Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines	0.05
OC	Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC	Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC	Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC	Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC	Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M	Total Coliforms (including fecal coliform and *E. coli*)	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.	zero
DBP	Total Trihalomethanes (TTHMs)	0.10 0.080 after 12/31/03	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC	2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC	1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC	1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.20
OC	1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC	Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero
M	Turbidity	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing micro-organisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero

LEGEND

D Dinsinfectant
DBP Disinfection Byproduct
IOC Inorganic Chemical
M Microorganism
OC Organic Chemical
R Radionuclides

4

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

NOTES

1 Definitions

- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium* (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- *Giardia lamblia*: 99.9% removal/inactivation
- Viruses: 99.99% removal/inactivation
- *Legionella*: No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing >10,000, and January 14, 2005, for systems servicing <10,000, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

4 No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

5 Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

6 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

7 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

8 Each water system must certify, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent).

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

National Secondary Drinking Water Standards

National Secondary Drinking Water Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Office of Water (4606M)
EPA 816-F-03-016
www.epa.gov/safewater
June 2003

APPENDIX B: SEVERN TRENT CHEMILUMINESCENCE TEST RESPONSE TO SUBSTANCES WITH DIFFERENT MODES OF TOXIC ACTION

Chemiluminescence Test (Eclox)

Response To Substances With Different Modes Of Toxic Action

MODE OF ACTION	COMPOUND	CURVE SHAPE	Limit Of Detection ($mg.l^{-1}$)
Polar narcotics	Phenol Aniline	Convex Concave	0.06 0.04
Respiratory blockers	Cyanide	Concave	0.005
Oxidative Uncouplers	2,4-dinitrophenol	S-shaped	0.7
Membrane irritants	Chlorine (free)* Acrolein	Concave S-shaped	0.004 0.9
Cholineterase inhibitors	Carbofuran	S-shaped	0.5
CNS convulsants	Endosulphan	-	1.2
Heavy metals	Arsenic Copper Mercury Chromium Zinc Cadmium Lead Thallium Antimony	Convex Convex Concave Convex Convex Concave Concave Convex Concave	38 1.0 1.0 92 5.0 5.0 5.0 7.0 7.0
Photosynthetic inhibitors	Prometon Bromacil	Convex Convex	900 210
Cell division inhibitors	Triflualin	Concave	4

Source: Wolfson Applied Technology Laboratory and Severn Trent Services internal report.

The effect of free chlorine can be removed using the preconditioner in the kit.

The responses above are typical of toxic chemicals. Hundreds of other toxic chemicals give similar responses.

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Table 6 ECL responses to substances with different modes of toxic action

Mode of action	Compound	Formula	Curve shape	LOD (molarity)	IC_{50} (molarity)	IC_{95} (molarity)	LOD ($mg.l^{-1}$)	IC_{50} ($mg.l^{-1}$)	IC_{95} ($mg.l^{-1}$)
Polar narcotics	Phenol	C_6H_6O	Convex	6×10^{-7}	5×10^{-6}	6.0×10^{-5}	0.06	0.6	7.5
	Aniline	C_6H_7N	Concave	4×10^{-7}	3×10^{-5}	6.6×10^{-3}	0.04	3.4	745
Respiratory blocker	Cyanide	KCN	Concave	8×10^{-7}	6×10^{-6}	3×10^{-2}	0.005	0.01	52
	Carbon monoxide	CO	Convex	-	-	-	-	-	-
Oxidative phos. Uncoupler	2,4-dinitrophenol	$C_6H_4N_2O_5$	S-shaped	1×10^{-5}	2×10^{-4}	2.8×10^{-3}	0.7	51	736
	pentochorophenol	C_6HCl_5O	Convex	4×10^{-4}	7×10^{-3}	1.9×10^{-2}	107	1918	5327
	hydrogen sulphide #	H_2S	Concave	8×10^{-5} moles	1×10^{-3} moles	-	$0.002mm^3$	$0.03mm^3$	-
Membrane irritant	Chlorine (free)	Cl	Concave	6×10^{-8}	4×10^{-7}	2×10^{-5}	0.004	0.03	1.6
	Acrolein	C_3H_4O	S-shaped	2×10^{-5}	6×10^{-4}	2×10^{-2}	0.9	27	897
Cholinesterase inhibitor	Carbofuran	$C_{12}H_{15}NO_3$	S-shaped	2×10^{-6}	2×10^{-5}	-	0.5	5.2	-
CNS convulsant	Endosulphan	$C_9H_6Cl_6O_3S$		3×10^{-6}	-	-	1.2	-	-
Heavy metals	Copper	$Cu(NO_3)_2\ 2.5H_2O$	Convex	9×10^{-7}	1×10^{-3}	3.8×10^{-3}	0.2	242	930
	Mercury	$Hg_2(NO_3)_2\ 2H_2O$	Concave	4×10^{-6}	4×10^{-5}	7.2×10^{-4}	0.3	16	288
	Chromium	$CrCl_3$	Convex	8×10^{-7}	2×10^{-4}	2.8×10^{-3}	1.3	86	1227
	Zinc	$ZnSO_4\ 4H_2O$	Convex	3×10^{-4}	5×10^{-3}	7.8×10^{-2}	92	152	2379
	Cadmium	$Cd(NO_3)_2\ 4H_2O$	Concave	8×10^{-4}	4×10^{-3}	1.1×10^{-1}	247	1114	30847
Photosynthetic inhibitor	Prometon		Convex	4×10^{-3}	8.5×10^{-3}	2×10^{-3}	901	1924	4506
	Bromacil		Convex	8×10^{-4}	1.7×10^{-2}	4×10^{-2}	209	4452	10444
Cell division inhibitor	Trifluralin	$C_{13}H_{16}F_3N_3O_4$	Concave	1×10^{-5}	8×10^{-5}	1.6×10^{-4}	4	33	67

- H_2S gas was bubbled through 10 ml of deionised water. Calculations for H_2S and CO gas assumed a perfect gas sphere, size 0.018 cm^3 per 1 cm^3 of water (volume $4/3\pi r^3$). Carbon monoxide was sparingly soluble in water. However, $724cm^3$ of gas caused 34% inhibition. The number of moles of gas assumes ideal gas at standard temperature and pressure. Free chlorine was produced using calcium hypochlorite, $Ca(OCl)_2$.

APPENDIX C: PESTICIDE TEST - TYPICAL PESTICIDE TEST STRIP DETECTION LIMITS

Pesticide Test

Typical Pesticide Test Strip Detection Limits

Common Names	Trade Names	Detection Limit In Water (ppm)	Detection Limit Using a Concentrator
Carbamates			
Aldicarb	Temik	0.2	
Carbaryl	Sevin	7.0	0.3
Carbofuran	Furaden	0.1	0.003
Mesurol	Methiocarb	5.0	0.1
Methomyl	Lannate	1.0	0.5
MIPC	Lannate	2.0	
Oxamyl	Vydate L	1.0	0.5
Propoxur	Baygon	1.0	
Organophosphates			
DDVP	Vapona	3.0	
Methamidophos	Monitor	4.0	
Mevinphos	Phosdrin	2.0	
Thiophosphates*			
Aspon	-	5.0	
Azinphos-Methyl	Guthion	0.3	0.05
Chlorpyrifos-Ethyl	Dursban, Lorsban	0.7	
Chlorpyrifos-Methyl	Reldan	1.0	0.2
Diazinon	Spectracide	2.0	0.3
EPN	-	0.2	
Fenitrothion	-	1.5	
Malathion	-	2.0	0.4
Metasystox-R	-	20.0	
Methyl -Parathion	-	4.0	1.6
Parathion	-	2.0	
Phorate	Thimet	3.0	
Phosmet	Prolate	1.0	
Phosvel	Leptophos	0.8	

*Requires conversion to oxygen analogue for detection

The use of a concentrator can improve the detection limits for all these pesticides, a number of examples are shown above.

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SEVERN TRENT SERVICES

APPENDIX D: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 1

Region 1

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: NEW ORLEANS CARROLTON WW
PWS ID 1071009 PROJECT 838
N O SEWERAGE WATER BOA
8800 S CLAIBORNE AVE
NEW ORLEANS LA 70118

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC48710 POC ID: 1BAQ-SNR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	2		0.02

Sample Comments:

Sample ID: AC48711 POC ID: 1BAQ-SSR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Loss on Ignition	mg/liter	206		1
Sulfate	mg/l as SO4	52		1
Chloride	mg/liter	36.0		10
Total Solids	mg/liter	410		1
Turbidity	N.T.U.'s	0.54		0.02
Color	Hazen units	5		1
pH measurement temperature	deg C	25		1
pH	units	8.47		0.04
Total Hardness	mg/l as CaCO3	103.1		2.0
Total Alkalinity	mg/l as CaCO3	110.1		0.60

Sample ID: AC48711 POC ID: 1BAQ-SSR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Fluoride	mg/liter	1.0		0.10
Iron	mg/liter	0.02		0.002
Manganese	mg/liter	0.00		0.0008
Sodium	mg/liter	19.6		0.02
Potassium	mg/liter	2.5		0.9

Sample Comments:

Sample ID: AC48712 POC ID: 1BAQ-SMR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Selenium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Thallium	mg/liter	PENDING		
Cadmium	mg/liter	0.000		0.001
Chromium	mg/liter	0.00		0.006
Silver	mg/liter	0.00		0.004
Arsenic	mg/liter	0.000		0.005
Mercury	mg/liter	0.000		0.001
Beryllium	mg/liter	0.000		0.0002
Nickel	mg/liter	0.0		0.005
Aluminum	mg/liter	0.11		0.020
Zinc	mg/liter	0		0.001
Barium	mg/liter	0		0.008

Sample ID: AC48712 POC ID: 1BAQ-SMR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample Comments:

Sample ID: AC48713 POC ID: 1BAQ-SOR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	0.0		1.20

Sample Comments:

Sample ID: AC48714 POC ID: 1BAQ-SRR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	2		2
Gross beta activity	pCi/liter	Less than		3

Sample Comments:

Sample ID: AC48725 POC ID: 1BAQ-SYR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected		0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected	*	0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	25.4	*	0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	10.1		0.19
Dibromomethane	micrograms/L	Not detected		0.29

Sample ID: AC48725 POC ID: 1BAQ-SYR

Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	2.5		0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected	*	0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected	*	0.40
Styrene	micrograms/L	Not detected	*	0.18
Bromoform	micrograms/L	Not detected	*	0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20

Sample ID: AC48725 POC ID: 1BAQ-SYR
Facility ID: 1071009
Point of Collection: LAB TAP, CARROLLTON WATER PLAN
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected	*	0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.
pH of VOC sample = 7

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX E: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 2

Region 2

Sample ID: AC48234 POC ID: 2MJW-SYR
Facility ID: 1033019
Point of Collection: SCENIC HWY WELL
Sample collector: CORKERN
Sample collection date: 03/16/2004 Time: 9:00:00 AM
Lab Submittal date: 03/17/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	Not detected		0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	Not detected		0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20

Sample ID: **AC48234** POC ID: 2MJW-SYR

Facility ID: 1033019
Point of Collection: SCENIC HWY WELL
Sample collector: CORKERN
Sample collection date: 03/16/2004 Time: 9:00:00 AM
Lab Submittal date: 03/17/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Chlorodibromomethane	micrograms/L	Not detected		0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected		0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected		0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected	*	0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected	*	0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25

Sample ID: AC48234 POC ID: 2MJW-SYR
Facility ID: 1033019
Point of Collection: SCENIC HWY WELL
Sample collector: CORKERN
Sample collection date: 03/16/2004 Time: 9:00:00 AM
Lab Submittal date: 03/17/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX F: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 3

Region 3

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: ST CHARLES WATER DIST 1
PWS ID 1089001 PROJECT 838
ST CHARLES WATER DIST 1
P O BOX 108
LULING LA 70070

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC48715 POC ID: 3CAA-SNR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	2		0.02

Sample Comments:

Sample ID: AC48716 POC ID: 3CAA-SSR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Fluoride	mg/liter	0.8		0.10
Sulfate	mg/l as SO4	44		1
Chloride	mg/liter	34.2		10
Loss on Ignition	mg/liter	108		1
Total Solids	mg/liter	242		1
Color	Hazen units	5		1
pH measurement temperature	deg C	25		1
pH	units	7.59		0.04
Total Alkalinity	mg/l as CaCO3	94.0		0.60
Total Hardness	mg/l as CaCO3	69.2		2.0

Sample ID: AC48716 POC ID: 3CAA-SSR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Turbidity	N.T.U.'s	0.14		0.02
Manganese	mg/liter	0.00		0.0008
Iron	mg/liter	0.03		0.002
Sodium	mg/liter	19.4		0.02
Potassium	mg/liter	2.7		0.9

Sample Comments:

Sample ID: AC48717 POC ID: 3CAA-SMR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Thallium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Selenium	mg/liter	PENDING		
Mercury	mg/liter	0.000		0.001
Nickel	mg/liter	0.0		0.005
Beryllium	mg/liter	0.000		0.0002
Cadmium	mg/liter	0.000		0.001
Barium	mg/liter	0		0.008
Arsenic	mg/liter	0.000		0.005
Silver	mg/liter	0.00		0.004
Aluminum	mg/liter	0.06		0.020
Zinc	mg/liter	0		0.001
Chromium	mg/liter	0.00		0.006

Sample ID: AC48717 POC ID: 3CAA-SMR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample Comments:

Sample ID: AC48718 POC ID: 3CAA-SOR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	0.0		1.20

Sample Comments:

Sample ID: AC48719 POC ID: 3CAA-SRR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 4:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	Less than		2
Gross beta activity	pCi/liter	Less than		3

Sample Comments:

Sample ID: AC48726 POC ID: 3CAA-SYR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected		0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected	*	0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	31.0	*	0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	16.4		0.19
Dibromomethane	micrograms/L	Not detected		0.29

Sample ID: AC48726 POC ID: 3CAA-SYR
Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	4.4		0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected	*	0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected	*	0.40
Styrene	micrograms/L	Not detected	*	0.18
Bromoform	micrograms/L	Not detected	*	0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20

Sample ID: **AC48726** POC ID: 3CAA-SYR

Facility ID: 1089001
Point of Collection: LAB TAP AT PLANT
Sample collector: DESSAUR
Sample collection date: 04/06/2004 Time: 12:00:00 AM
Lab Submittal date: 04/07/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected	*	0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.
pH of VOC sample = 7

APPENDIX G: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 4

Region 4

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: W W DISTRICT 1 ESTHER
PWS ID 1113035 PROJECT 838
WW DIST 1 NORTH VERMILION
11822 LA HWY 699
MAURICE LA 70555

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC49410 POC ID: 4HPA-SNR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	PENDING		

Sample Comments:

Sample ID: AC49411 POC ID: 4HPA-SSR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample ID: AC49411 POC ID: 4HPA-SSR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Loss on Ignition	mg/liter	PENDING		
Sulfate	mg/l as SO4	PENDING		
Chloride	mg/liter	PENDING		
Total Solids	mg/liter	PENDING		
Turbidity	N.T.U.'s	PENDING		
Color	Hazen units	PENDING		
pH measurement temperature	deg C	PENDING		
pH	units	PENDING		
Total Alkalinity	mg/l as CaCO3	PENDING		
Fluoride	mg/liter	PENDING		
Total Hardness	mg/l as CaCO3	170.9		2.0
Iron	mg/liter	1.08		0.002
Manganese	mg/liter	0.12		0.0008
Sodium	mg/liter	41.7		0.02
Potassium	mg/liter	1.5		0.9

Sample Comments:

Sample ID: AC49412 POC ID: 4HPA-SMR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Selenium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Thallium	mg/liter	PENDING		
Cadmium	mg/liter	0.000		0.001

Sample ID: AC49412 POC ID: 4HPA-SMR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Chromium	mg/liter	0.00		0.006
Mercury	mg/liter	0.000		0.001
Arsenic	mg/liter	0.000		0.005
Aluminum	mg/liter	0.06		0.020
Beryllium	mg/liter	0.000		0.0002
Nickel	mg/liter	0.0		0.005
Silver	mg/liter	0.00		0.004
Zinc	mg/liter	0		0.001
Barium	mg/liter	0		0.008

Sample Comments:

Sample ID: AC49413 POC ID: 4HPA-SOR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	PENDING		

Sample Comments:

Sample ID: AC49414 POC ID: 4HPA-SRR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample ID: AC49414 POC ID: 4HPA-SRR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	2		2
Gross beta activity	pCi/liter	Less than		3

Sample Comments:

Sample ID: AC49419 POC ID: 4HPA-SYR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected		0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected		0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected	*	0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27

Sample ID: AC49419 POC ID: 4HPA-SYR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Chloroform	micrograms/L	Not detected	*	0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected	*	0.30
Carbon Tetrachloride	micrograms/L	Not detected	*	0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected	*	0.24
1,2-Dichloroethane	micrograms/L	Not detected	*	0.33
Trichloroethylene	micrograms/L	Not detected	*	0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	Not detected	*	0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected	*	0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	Not detected	*	0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected		0.23
Ethylbenzene	micrograms/L	Not detected	*	0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected	*	0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected		0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33

Sample ID: AC49419 POC ID: 4HPA-SYR
Facility ID: 1113035
Point of Collection: TAP AT WELL #1
Sample collector: LANGE, S.
Sample collection date: 05/03/2004 Time: 2:15:00 PM
Lab Submittal date: 05/05/2004 Time: 3:00:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected		0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX H: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 5

Region 5

Sample ID: AC42136 POC ID: 5CVW-SNR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	0		0.02

Sample Comments:

Sample ID: AC42137 POC ID: 5CVW-SSR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Turbidity	N.T.U.'s	8.8		0.02
Sulfate	mg/l as SO4	2		1
Fluoride	mg/liter	0.1		0.10
Chloride	mg/liter	138.6		10
Total Solids	mg/liter	402		1
pH measurement temperature	deg C	24		1

Sample ID: AC42137 POC ID: 5CVW-SSR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
pH	units	7.07		0.04
Total Hardness	mg/l as CaCO3	84.0		2.0
Total Alkalinity	mg/l as CaCO3	141.6		0.60
Loss on Ignition	mg/liter	54		1
Color	Hazen units	20		1
Manganese	mg/liter	0.46		0.0008
Sodium	mg/liter	83.1		0.02
Iron	mg/liter	1.95		0.002
Potassium	mg/liter	2.4		0.9

Sample Comments:

Sample ID: AC42138 POC ID: 5CVW-SMR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Selenium	mg/liter	0.00		0.01
Thallium	mg/liter	0.000		0.001
Aluminum	mg/liter	0.00		0.020
Nickel	mg/liter	0.0		0.005
Zinc	mg/liter	0		0.001
Beryllium	mg/liter	0.000		0.0002
Antimony	mg/liter	0.000		0.003
Chromium	mg/liter	0.00		0.006
Cadmium	mg/liter	0.000		0.001
Arsenic	mg/liter	0.00		0.005

Sample ID: AC42138 POC ID: 5CVW-SMR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Silver	mg/liter	0.01		0.004
Barium	mg/liter	0		0.008
Mercury	mg/liter	0.000		0.001

Sample Comments:

Sample ID: AC42139 POC ID: 5CVW-SOR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	0.0		1.20

Sample Comments:

Sample ID: AC42140 POC ID: 5CVW-SRR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	Less than		2
Gross beta activity	pCi/liter	Less than		3

Sample ID: AC42140 POC ID: 5CVW-SRR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Sample Comments:				

Sample ID: AC42149 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected		0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected		0.19
BENZO(a)PYRENE	Micrograms/L	Not detected		0.11
Synthetic organic contaminants				
DALAPON	Micrograms/L	Not detected	*	0.53
2,4-D	Micrograms/L	Not detected		0.08
DINOSEB	Micrograms/L	Not detected		0.49
PICLORAM	Micrograms/L	Not detected	*	0.06
PENTACHLOROPHENOL	Micrograms/L	Not detected		0.016
2,4,5-TP(SILVEX)	Micrograms/L	Not detected		0.06
ATRAZINE	Micrograms/L	Not detected		0.19
ALACHLOR	Micrograms/L	Not detected		0.028
CHLORDANE	Micrograms/L	Not detected		0.02
ENDRIN	Micrograms/L	Not detected	*	0.006
HEPTACHLOR	Micrograms/L	Not detected		0.011
HEPTACHLOR EPOXIDE	Micrograms/L	Not detected	*	0.003
HEXACHLOROBENZENE	Micrograms/L	Not detected		0.004
HEXACHLOROCYCLOPENTADIENE	Micrograms/L	Not detected	*	0.116

Sample ID: AC42149 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/16/2003 Time: 9:00:00 AM
Lab Submittal date: 09/17/2003 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Synthetic organic contaminants				
LINDANE	Micrograms/L	Not detected		0.004
METHOXYCHLOR	Micrograms/L	Not detected	*	0.099
SIMAZINE	Micrograms/L	Not detected		1.5
TOXAPHENE	Micrograms/L	Not detected		0.1
PCB's(SCREEN)	Micrograms/L	Not detected		0.1
ALDICARB SULFONE	Micrograms/L	Not detected		0.13
ALDICARB SULFOXIDE	Micrograms/L	Not detected		0.25
OXAMYL(VYDATE)	Micrograms/L	Not detected		0.40
METHOMYL	Micrograms/L	Not detected		0.37
ALDICARB	Micrograms/L	Not detected		0.35
CARBOFURAN	Micrograms/L	Not detected		0.55
DIQUAT	Micrograms/L	Not detected		0.39
GLYPHOSATE	Micrograms/L	Not detected		3.7
ENDOTHALL	Micrograms/L	Not detected		2.39

Sample Comments:
Note: VOC sample rejected for analysis; contained air bubble.

Sample ID: AC42893 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/29/2003 Time: 11:00:00 AM
Lab Submittal date: 10/01/2003 Time: 2:35:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38

Sample ID: AC42893 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/29/2003 Time: 11:00:00 AM
Lab Submittal date: 10/01/2003 Time: 2:35:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	Not detected		0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	Not detected		0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	Not detected		0.22
1,2-Dibromoethane (EDB)	micrograms/L	NOT DONE		0.20
Chlorobenzene	micrograms/L	Not detected		0.23

Sample ID: AC42893 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/29/2003 Time: 11:00:00 AM
Lab Submittal date: 10/01/2003 Time: 2:35:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected		0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	NOT DONE		0.010
1,2,4-Trichlorobenzene	micrograms/L	Not detected		0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample ID: AC42893 POC ID: 5CVW-SYR
Facility ID: 1019029
Point of Collection: TAP ON WELL G#10-WEST PLANT
Sample collector: PIPER - 0832
Sample collection date: 09/29/2003 Time: 11:00:00 AM
Lab Submittal date: 10/01/2003 Time: 2:35:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample Comments:
* QC out of control for this analyte.
Resubmit sample for EPA 504.1 analysis (EDB,DBCP)

APPENDIX I: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 6

Region 6

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: ALEXANDRIA CITY OF
PWS ID 1079001 PROJECT 838
CITY OF ALEXANDRIA
2021 INDUSTRIAL PARK BVD
ALEXANDRIA LA 71303

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC48582 POC ID: 6IFI-SNR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	0		0.02

Sample Comments:

Sample ID: AC48583 POC ID: 6IFI-SSR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Chloride	mg/liter	13.0		10
Fluoride	mg/liter	1.1		0.10
Loss on Ignition	mg/liter	4		1
Total Solids	mg/liter	388		1
Turbidity	N.T.U.'s	0.22		0.02
pH measurement temperature	deg C	25		1
pH	units	7.52		0.04
Total Hardness	mg/l as CaCO3	3.1		2.0
Total Alkalinity	mg/l as CaCO3	158.9		0.60
Sulfate	mg/l as SO4	Less than		1
Color	Hazen units	5		1
Manganese	mg/liter	0.01		0.0008
Sodium	mg/liter	90.8		0.02
Iron	mg/liter	0.05		0.002
Potassium	mg/liter	2.1		0.9

Sample Comments:

Sample ID: AC48584 POC ID: 6IFI-SMR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Thallium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Selenium	mg/liter	PENDING		
Mercury	mg/liter	0.000		0.001

Sample ID: AC48584 POC ID: 6IFI-SMR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nickel	mg/liter	0.0		0.005
Beryllium	mg/liter	0.000		0.0002
Cadmium	mg/liter	0.000		0.001
Barium	mg/liter	0		0.008
Arsenic	mg/liter	0.000		0.005
Silver	mg/liter	0.00		0.004
Aluminum	mg/liter	0.03		0.020
Zinc	mg/liter	0		0.001
Chromium	mg/liter	0.00		0.006

Sample Comments:

Sample ID: AC48585 POC ID: 6IFI-SOR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	0.0		1.20

Sample Comments:

Sample ID: AC48586 POC ID: 6IFI-SRR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample ID: AC48586 POC ID: 6IFI-SRR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	Less than		2
Gross beta activity	pCi/liter	Less than		3

Sample Comments:

Sample ID: AC48589 POC ID: 6IFI-SYR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected	*	0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected		0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11
Synthetic organic contaminants				
DALAPON	Micrograms/L	Not detected		0.53
2,4-D	Micrograms/L	Not detected		0.08
DINOSEB	Micrograms/L	Not detected		0.49

Sample ID: AC48589 POC ID: 6IFI-SYR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Synthetic organic contaminants				
PICLORAM	Micrograms/L	Not detected		0.06
PENTACHLOROPHENOL	Micrograms/L	Not detected		0.016
2,4,5-TP(SILVEX)	Micrograms/L	Not detected		0.06
ATRAZINE	Micrograms/L	Not detected		0.19
ALACHLOR	Micrograms/L	Not detected		0.028
CHLORDANE	Micrograms/L	Not detected		0.02
ENDRIN	Micrograms/L	Not detected		0.006
HEPTACHLOR	Micrograms/L	Not detected		0.011
HEPTACHLOR EPOXIDE	Micrograms/L	Not detected		0.003
HEXACHLOROBENZENE	Micrograms/L	Not detected		0.004
HEXACHLOROCYCLOPENTADIENE	Micrograms/L	Not detected	*	0.116
LINDANE	Micrograms/L	Not detected		0.004
METHOXYCHLOR	Micrograms/L	Not detected	*	0.099
SIMAZINE	Micrograms/L	Not detected		1.5
TOXAPHENE	Micrograms/L	Not detected		0.1
PCB's(SCREEN)	Micrograms/L	Not detected		0.1
ALDICARB SULFONE	Micrograms/L	Not detected		0.13
ALDICARB SULFOXIDE	Micrograms/L	Not detected		0.25
OXAMYL(VYDATE)	Micrograms/L	Not detected		0.40
METHOMYL	Micrograms/L	Not detected		0.37
ALDICARB	Micrograms/L	Not detected		0.35
CARBOFURAN	Micrograms/L	Not detected		0.55
DIQUAT	Micrograms/L	Not detected		0.39
GLYPHOSATE	Micrograms/L	Not detected		3.7
ENDOTHALL	Micrograms/L	Not detected	*	2.39
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50

Sample ID: AC48589 POC ID: 6IFI-SYR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	Not detected		0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	Not detected		0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected	*	0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	Not detected		0.22

Sample ID: AC48589 POC ID: 6IFI-SYR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected		0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected	*	0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected		0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26

Sample ID: AC48589 POC ID: 6IFI-SYR
Facility ID: 1079001
Point of Collection: ALEXANDRIA WELL R-1330
Sample collector: DOWTY
Sample collection date: 03/29/2004 Time: 12:00:00 AM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX J: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 7

Region 7

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: SHREVEPORT WATER SYSTEM
PWS ID 1017031 PROJECT 838
CITY OF SHREVEPORT
P O BOX 31109
SHREVEPORT LA 71130

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC48613 POC ID: 7KCT-SNR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	0		0.02

Sample Comments:

Sample ID: AC48614 POC ID: 7KCT-SSR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Total Solids	mg/liter	857		1
Total Alkalinity	mg/l as CaCO3	26.3		0.60
Total Hardness	mg/l as CaCO3	24.2		2.0
pH	units	9.04		0.04
pH measurement temperature	deg C	25		1
Color	Hazen units	5		1
Loss on Ignition	mg/liter	176		1
Chloride	mg/liter	27.1		10
Fluoride	mg/liter	0.8		0.10
Sulfate	mg/l as SO4	43		1
Turbidity	N.T.U.'s	0.1		0.02
Iron	mg/liter	0.07		0.002
Manganese	mg/liter	0.01		0.0008
Sodium	mg/liter	26.6		0.02
Potassium	mg/liter	2.2		0.9

Sample Comments:

Sample ID: AC48615 POC ID: 7KCT-SMR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Selenium	mg/liter	PENDING		
Thallium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Zinc	mg/liter	0		0.001

Sample ID: AC48615 POC ID: 7KCT-SMR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cadmium	mg/liter	0.000		0.001
Chromium	mg/liter	0.00		0.006
Mercury	mg/liter	0.000		0.001
Beryllium	mg/liter	0.000		0.0002
Arsenic	mg/liter	0.000		0.005
Aluminum	mg/liter	0.08		0.020
Nickel	mg/liter	0.0		0.005
Silver	mg/liter	0.00		0.004
Barium	mg/liter	0		0.008

Sample Comments:

Sample ID: AC48616 POC ID: 7KCT-SOR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	0.0		1.20

Sample Comments:

Sample ID: AC48617 POC ID: 7KCT-SRR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample ID: AC48617 POC ID: 7KCT-SRR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross beta activity	pCi/liter	Less than		3
Gross alpha activity	pCi/liter	Less than		2

Sample Comments:

Sample ID: AC48620 POC ID: 7KCT-SYR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	Not detected	*	0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected		0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11
Synthetic organic contaminants				
DALAPON	Micrograms/L	Not detected		0.53
2,4-D	Micrograms/L	Not detected		0.08
DINOSEB	Micrograms/L	Not detected		0.49
PICLORAM	Micrograms/L	Not detected		0.06
PENTACHLOROPHENOL	Micrograms/L	Not detected		0.016
2,4,5-TP(SILVEX)	Micrograms/L	Not detected		0.06
ATRAZINE	Micrograms/L	Not detected		0.19
ALACHLOR	Micrograms/L	Not detected		0.028
CHLORDANE	Micrograms/L	Not detected		0.02
ENDRIN	Micrograms/L	Not detected		0.006
HEPTACHLOR	Micrograms/L	Not detected		0.011
HEPTACHLOR EPOXIDE	Micrograms/L	Not detected		0.003

Sample ID: AC48620 POC ID: 7KCT-SYR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Synthetic organic contaminants				
HEXACHLOROBENZENE	Micrograms/L	Not detected		0.004
HEXACHLOROCYCLOPENTADIENE	Micrograms/L	Not detected	*	0.116
LINDANE	Micrograms/L	Not detected		0.004
METHOXYCHLOR	Micrograms/L	Not detected	*	0.099
SIMAZINE	Micrograms/L	Not detected		1.5
TOXAPHENE	Micrograms/L	Not detected		0.1
PCB's(SCREEN)	Micrograms/L	Not detected		0.1
ALDICARB SULFONE	Micrograms/L	Not detected		0.13
ALDICARB SULFOXIDE	Micrograms/L	Not detected		0.25
OXAMYL(VYDATE)	Micrograms/L	Not detected		0.40
METHOMYL	Micrograms/L	Not detected		0.37
ALDICARB	Micrograms/L	Not detected		0.35
CARBOFURAN	Micrograms/L	Not detected		0.55
DIQUAT	Micrograms/L	Not detected		0.39
GLYPHOSATE	Micrograms/L	Not detected		3.7
ENDOTHALL	Micrograms/L	Not detected	*	2.39
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41

Sample ID: AC48620 POC ID: 7KCT-SYR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	6.5		0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	2.7		0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected	*	0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	1.1		0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected		0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected	*	0.21
Isopropylbenzene	micrograms/L	Not detected		0.33

Sample ID: AC48620 POC ID: 7KCT-SYR
Facility ID: 1017031
Point of Collection: *D*AMISS TREATMENT PLANT
Sample collector: STOUT
Sample collection date: 03/30/2004 Time: 12:30:00 PM
Lab Submittal date: 03/31/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected		0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected		0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

Sample Comments:
* QC out of control for this analyte.

APPENDIX K: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 8

Region 8

From: LOUISIANA DEPT OF HEALTH && HOSPITALS
CENTRAL LABORATORY
325 LOYOLA AVE. 7TH FLOOR
NEW ORLEANS, LA 70112
(504) 568-5371

Friday, June 04, 2004

To: PUNKIN CENTER HILLTOP WS
PWS ID 1049013 PROJECT 838
PUNKIN CENTER HILLTOP WS
6853 QUITMAN HWY
QUITMAN LA 71268

The following analytical results have been obtained for the indicated sample(s) which was submitted to this laboratory:

Sample ID: AC49814 POC ID: 8DMH-SNR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nitrate-N	mg/liter	PENDING		

Sample Comments:

Sample ID: AC49815 POC ID: 8DMH-SSR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Turbidity	N.T.U.'s	PENDING		
Total Alkalinity	mg/l as CaCO3	PENDING		
Total Hardness	mg/l as CaCO3	PENDING		
pH	units	PENDING		
Color	Hazen units	PENDING		
Total Solids	mg/liter	PENDING		
Loss on Ignition	mg/liter	PENDING		
Chloride	mg/liter	PENDING		
Fluoride	mg/liter	PENDING		
Sulfate	mg/l as SO4	PENDING		
pH measurement temperature	deg C	PENDING		
Manganese	mg/liter	PENDING		
Sodium	mg/liter	PENDING		
Iron	mg/liter	PENDING		
Potassium	mg/liter	PENDING		

Sample Comments:

Sample ID: AC49816 POC ID: 8DMH-SMR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Chromium	mg/liter	PENDING		
Antimony	mg/liter	PENDING		
Zinc	mg/liter	PENDING		
Thallium	mg/liter	PENDING		

Sample ID: AC49816 POC ID: 8DMH-SMR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Nickel	mg/liter	PENDING		
Beryllium	mg/liter	PENDING		
Silver	mg/liter	PENDING		
Cadmium	mg/liter	PENDING		
Barium	mg/liter	PENDING		
Arsenic	mg/liter	PENDING		
Aluminum	mg/liter	PENDING		
Selenium	mg/liter	PENDING		
Mercury	mg/liter	0.000		0.001

Sample Comments:

Sample ID: AC49817 POC ID: 8DMH-SOR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Cyanide	ppb	PENDING		

Sample Comments:

Sample ID: AC49818 POC ID: 8DMH-SRR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL

Sample ID: AC49818 POC ID: 8DMH-SRR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Gross alpha activity	pCi/liter	Less than		2
Gross beta activity	pCi/liter	Less than		3

Sample Comments:

Sample ID: AC49831 POC ID: 8DMH-SYR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S---ADIPATES/PHTHALATES				

Sample ID: AC49831 POC ID: 8DMH-SYR
Facility ID: 1049013
Point of Collection: WELL #3
Sample collector: GREEN
Sample collection date: 05/10/2004 Time: 10:05:00 AM
Lab Submittal date: 05/12/2004 Time: 2:30:00 PM

Component Name	Units	Results	Qualifier	Component MDL
PAH'S--- ADIPATES/PHTHALATES				
BIS (2-ETHYLHEXYL) PHTHALATE	Micrograms/L	2.29		0.12
BIS (2-ETHYLHEXYL) ADIPATE	Micrograms/L	Not detected		0.19
BENZO(a)PYRENE	Micrograms/L	Not detected	*	0.11

Sample Comments:
* QC out of control for this analyte.

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX L: OFFICE OF PUBLIC HEALTH, CENTRAL LAB REPORT REGION 9

Region 9

Sample ID: AC48170 POC ID: 9CSW-SYR
Facility ID: 1103124
Point of Collection: TAP AT ARROWOOD WELL
Sample collector: DRESSIER
Sample collection date: 03/15/2004 Time: 10:33:00 AM
Lab Submittal date: 03/16/2004 Time: 2:45:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
Dichlorodifluoromethane	micrograms/L	Not detected		0.50
Chloromethane	micrograms/L	Not detected		0.50
Vinyl Chloride	micrograms/L	Not detected		0.38
Bromomethane	micrograms/L	Not detected		0.45
Chloroethane	micrograms/L	Not detected		0.22
Fluorotrichloromethane	micrograms/L	Not detected		0.27
1,1-Dichloroethylene	micrograms/L	Not detected		0.22
Dichloromethane	micrograms/L	Not detected		0.16
trans-1,2-Dichloroethylene	micrograms/L	Not detected		0.30
1,1-Dichloroethane	micrograms/L	Not detected		0.41
2,2-Dichloropropane	micrograms/L	Not detected		0.17
cis-1,2-Dichloroethylene	micrograms/L	Not detected		0.27
Chloroform	micrograms/L	Not detected		0.42
Bromochloromethane	micrograms/L	Not detected		0.44
1,1,1-Trichloroethane	micrograms/L	Not detected		0.30
Carbon Tetrachloride	micrograms/L	Not detected		0.27

Sample ID: AC48170 POC ID: 9CSW-SYR
Facility ID: 1103124
Point of Collection: TAP AT ARROWOOD WELL
Sample collector: DRESSIER
Sample collection date: 03/15/2004 Time: 10:33:00 AM
Lab Submittal date: 03/16/2004 Time: 2:45:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
1,1-Dichloropropene	micrograms/L	Not detected		0.28
Benzene	micrograms/L	Not detected		0.24
1,2-Dichloroethane	micrograms/L	Not detected		0.33
Trichloroethylene	micrograms/L	Not detected		0.24
1,2-Dichloropropane	micrograms/L	Not detected		0.21
Bromodichloromethane	micrograms/L	Not detected		0.19
Dibromomethane	micrograms/L	Not detected		0.29
Toluene	micrograms/L	Not detected		0.24
1,3-Dichloropropene	micrograms/L	Not detected		0.18
1,1,2-Trichloroethane	micrograms/L	Not detected		0.14
Tetrachloroethylene	micrograms/L	Not detected		0.34
1,3-Dichloropropane	micrograms/L	Not detected		0.20
Chlorodibromomethane	micrograms/L	Not detected		0.22
1,2-Dibromoethane (EDB)	micrograms/L	Not detected		0.005
Chlorobenzene	micrograms/L	Not detected		0.23
Ethylbenzene	micrograms/L	Not detected		0.26
1,1,1,2-Tetrachloroethane	micrograms/L	Not detected		0.19
m & p-Xylene	micrograms/L	Not detected		0.46
o-Xylene	micrograms/L	Not detected		0.40
Styrene	micrograms/L	Not detected		0.18
Bromoform	micrograms/L	Not detected		0.21
Isopropylbenzene	micrograms/L	Not detected		0.33
1,1,2,2-Tetrachloroethane	micrograms/L	Not detected		0.19
Bromobenzene	micrograms/L	Not detected		0.33
1,2,3-Trichloropropane	micrograms/L	Not detected		0.37
n-Propylbenzene	micrograms/L	Not detected		0.27
2-Chlorotoluene	micrograms/L	Not detected		0.23
1,3,5-Trimethylbenzene	micrograms/L	Not detected		0.27

Sample ID: AC48170 POC ID: 9CSW-SYR
Facility ID: 1103124
Point of Collection: TAP AT ARROWOOD WELL
Sample collector: DRESSIER
Sample collection date: 03/15/2004 Time: 10:33:00 AM
Lab Submittal date: 03/16/2004 Time: 2:45:00 PM

Component Name	Units	Results	Qualifier	Component MDL
Volatile organic contaminants				
4-Chlorotoluene	micrograms/L	Not detected		0.23
tert-Butylbenzene	micrograms/L	Not detected		0.34
1,2,4-Trimethylbenzene	micrograms/L	Not detected		0.27
sec-Butylbenzene	micrograms/L	Not detected		0.29
1,4-Isopropyltoluene	micrograms/L	Not detected		0.36
m-Dichlorobenzene	micrograms/L	Not detected		0.25
p-Dichlorobenzene	micrograms/L	Not detected	*	0.20
n-Butylbenzene	micrograms/L	Not detected		0.26
o-Dichlorobenzene	micrograms/L	Not detected	*	0.22
1,2-Dibromo-3-Chloropropane (DBCP)	micrograms/L	Not detected		0.003
1,2,4-Trichlorobenzene	micrograms/L	Not detected	*	0.27
Hexachlorobutadiene	micrograms/L	Not detected		0.25
Napthalene	micrograms/L	Not detected		0.26
1,2,3-Trichlorobenzene	micrograms/L	Not detected		0.27
Methyl t-butyl ether (MTBE)	micrograms/L	Not detected		0.47

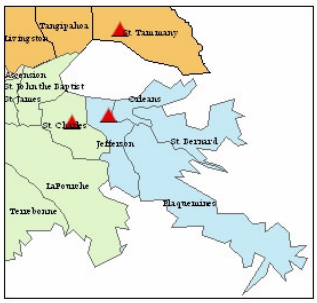
Sample Comments:
* QC out of control for this analyte.

If there are any questions regarding this data, please call.

Louis P. Wales, Jr.
Lab Scientist Manager

APPENDIX M: MAP OF REGION 1 WATER SAMPLING SITE

State of Louisiana
Public Health Region 1
Water Sampling Site - Surface Water Treatment Plant
Mississippi River
New Orleans Carrollton Water Way



Legend

- Water Sampling Sites
- Interstates
- Louisiana Roads
- Major Streams and Rivers

Water bodies (Lakes, Bays, ...)
Water features

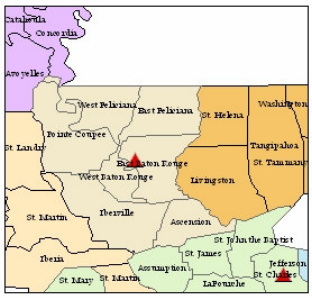
- Bay or Estuary or Ocean
- Stream
- Lake
- Lake Intermittent
- Lake Dry
- Reservoir
- Reservoir Intermittent
- Canal
- Glacier
- Swamp or Marsh

0.08 0.04 0 0.08 Miles

Louisiana Department of Health and Hospitals
Office of Public Health
Bioterrorism Response Unit

APPENDIX N: MAP OF REGION 2 WATER SAMPLING SITE

State of Louisiana
Public Health Region 2
Water Sampling Site - Scenic Highway Treatment Plant
Parish Water Company



Legend

- Water Sampling Sites
- Interstates
- Louisiana Roads
- Major Streams and Rivers

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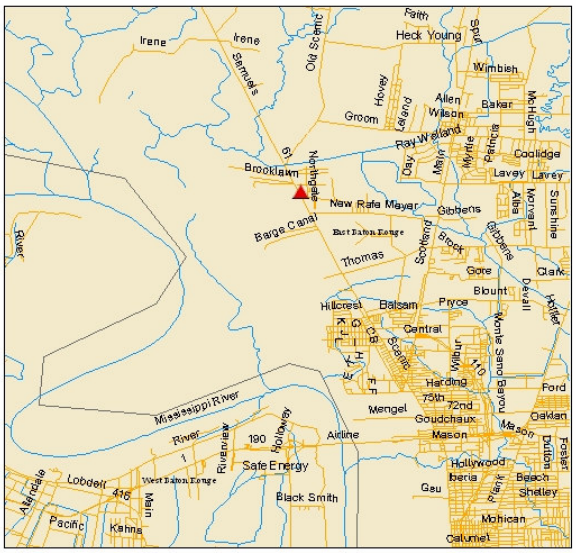
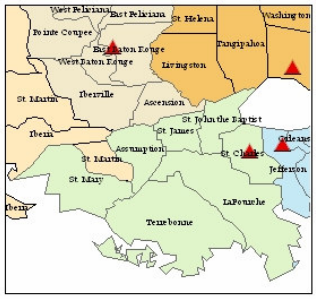
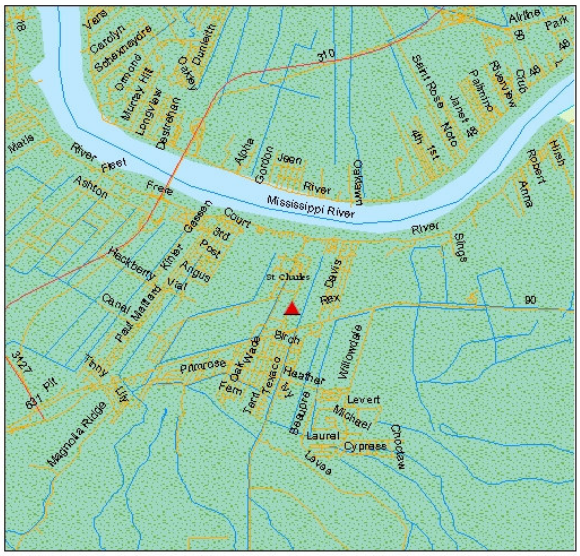
Office of Public Health
Bioterrorism Response Unit



APPENDIX O: MAP OF REGION 3 WATER SAMPLING SITE

State of Louisiana
Public Health Region 3
Water Sampling Site - Surface Water Treatment Plant
Mississippi River
St. Charles Water District #1





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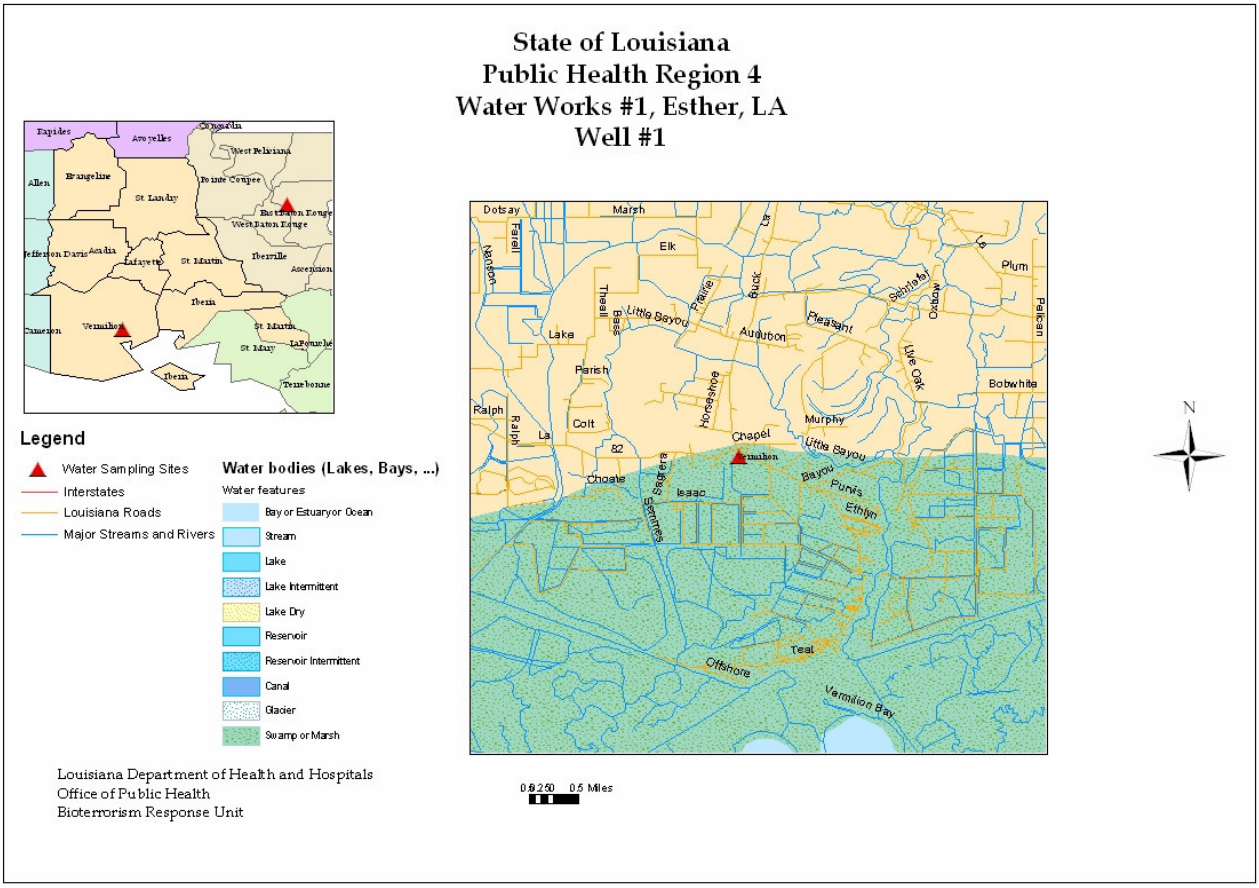
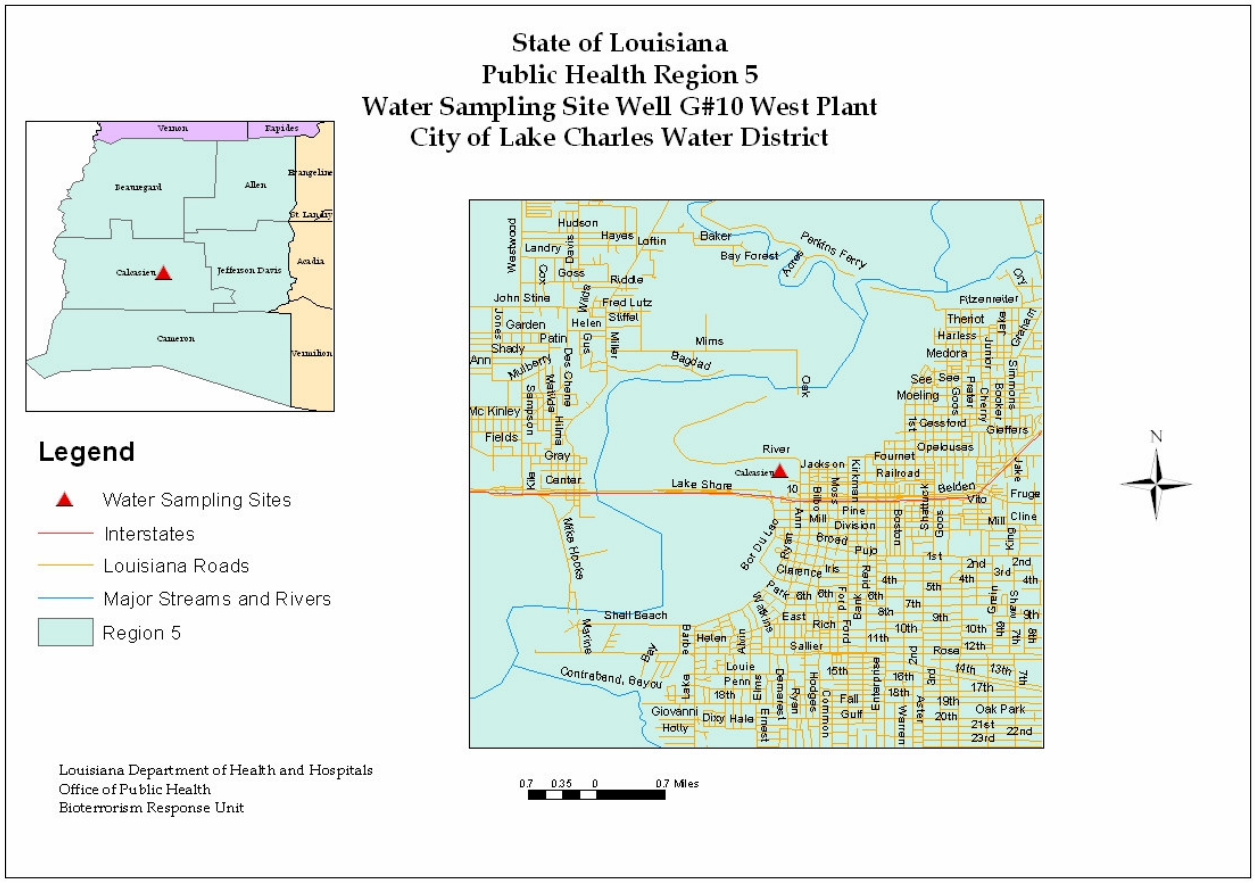
Office of Public Health
Bioterrorism Response Unit

APPENDIX P: MAP OF REGION 4 WATER SAMPLING SITE

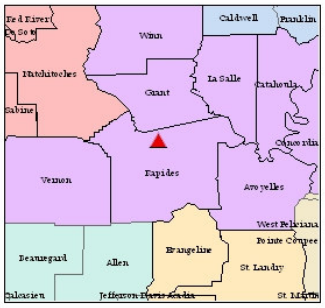


APPENDIX Q: MAP OF REGION 5 WATER SAMPLING SITE



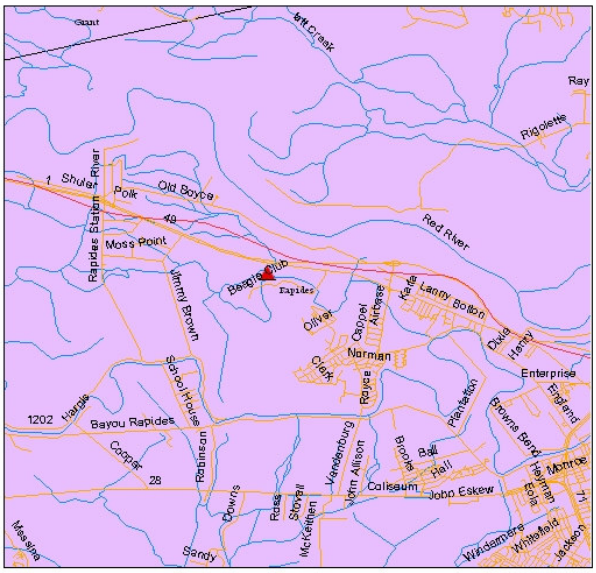
APPENDIX R: MAP OF REGION 6 WATER SAMPLING SITE

State of Louisiana
Public Health Region 6
Water Sampling Site - Chlorination Treatment Plant
Hwy.1 Well R-1330
City of Alexandria



Legend

- Water Sampling Sites
- Interstates
- Louisiana Roads
- Major Streams and Rivers



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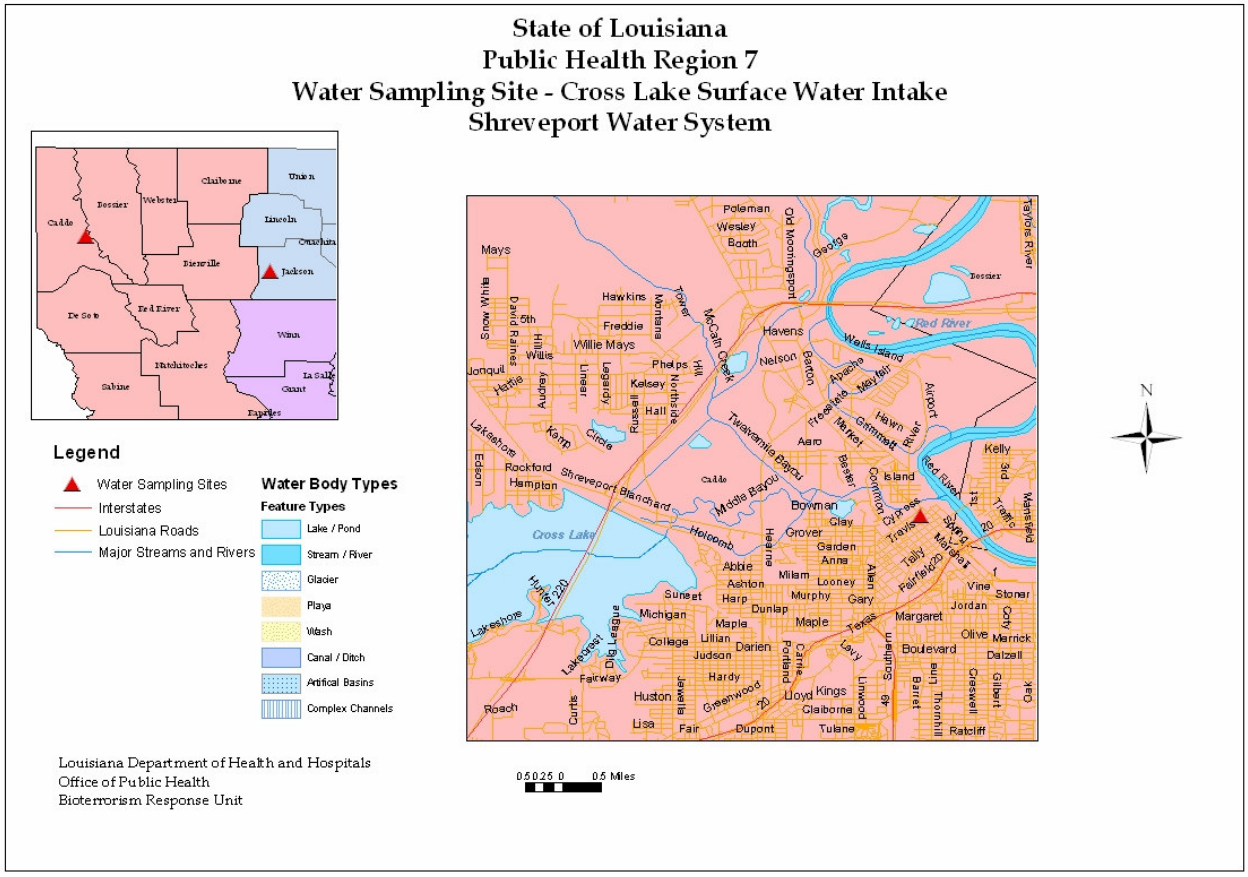
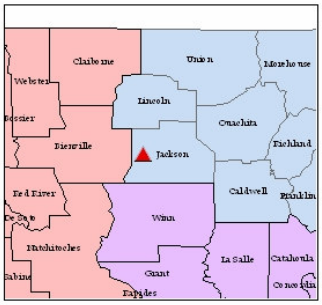
Office of Public Health
Bioterrorism Response Unit

APPENDIX S: MAP OF REGION 7 WATER SAMPLING SITE



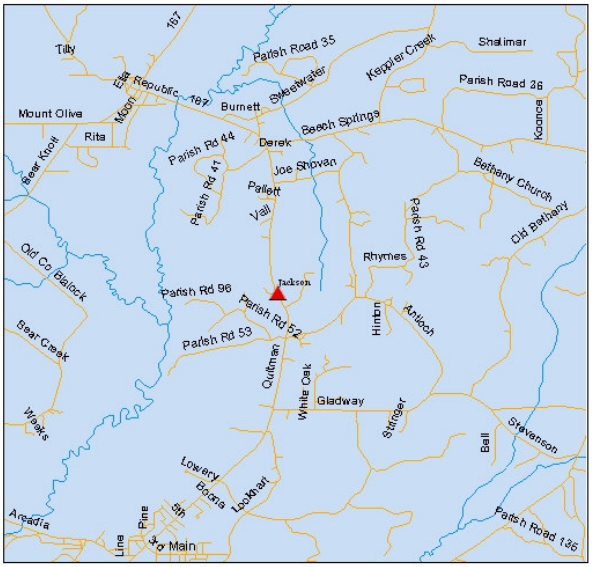
APPENDIX T: MAP OF REGION 8 WATER SAMPLING SITE

State of Louisiana
Public Health Region 8
Water Sampling Site - Well #3
Punkin Center Hilltop Water System



Legend

- Water Sampling Sites
- Interstates
- Louisiana Roads
- Major Streams and Rivers



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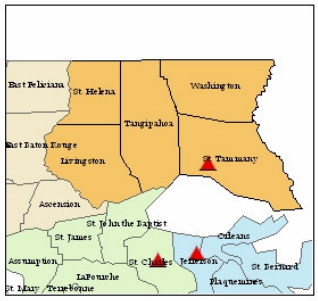
Bioterrorism Response Unit

APPENDIX U: MAP OF REGION 9 WATER SAMPLING SITE

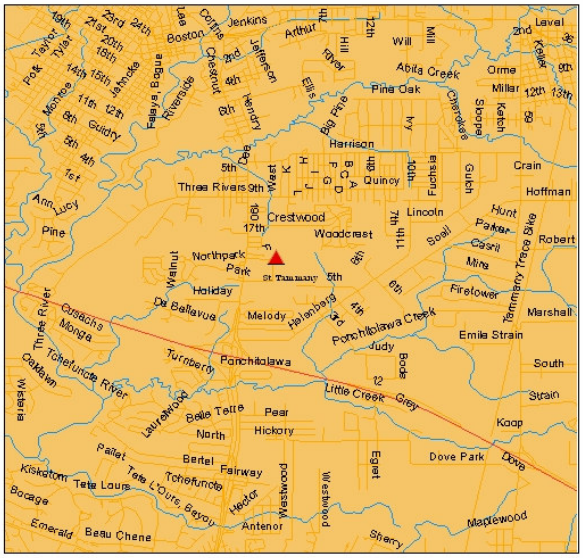
State of Louisiana
Public Health Region 9
Water Sampling Site - Tap at Arrowood Well
North Park Water Supply



Legend

- Water Sampling Sites
- Interstates
- Louisiana Roads
- Major Streams and Rivers

Louisiana Department of Health and Hospitals
Office of Public Health
Bioterrorism Response Unit



VITA

Jessica Coleman was born in Baton Rouge, Louisiana, on December 19, 1978. She is the daughter of Mr. and Mrs. David Coleman of Baker, Louisiana. She attended Louisiana State University and received a Bachelor of Science degree in zoology with a marine biology concentration in May 2000. She moved to and worked in Stuart, Florida, for roughly a year and a half before deciding to move back to Baton Rouge to pursue a master's degree in environmental sciences. During her tenure in the Department of Environmental Studies, she had the good fortune of being elected President of the Environmental Graduate Organization where she was able to plan and participate in many environmentally important projects in the LSU and Baton Rouge communities. Before defending her thesis, she started a job in Vicksburg, Mississippi, with Applied Research Associates, Inc. Ms. Coleman is currently a candidate for a Master of Science in environmental sciences to be awarded on December 17, 2004.